WOODWORKING

A HANDBOOK FOR BEGINNERS

TOOLS AND HOW TO USE THEM

CHARLES G. WHEELER

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WOODWORKING

A HANDBOOK FOR BEGINNERS IN HOME AND SCHOOL

TREATING OF

TOOLS AND OPERATIONS

BY

CHARLES G. WHEELER

AUTHOR OF "WOODWORKING FOR BEGINNERS"
AND "THE A B C OF WOODWORKING"

WITH OVER 800 ILLUSTRATIONS

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To the

BOY SCOUTS OF AMERICA

From One of the Advisors

to the

National Court of Honour

PREFACE

The aim has been to make this working handbook sufficiently simple, concise, and comprehensive to be suitable for everyone, from the young beginner to the student or amateur of mature years—for everybody except those already well trained in the subject, and possibly some of the latter class may find in it something of value to them. It contains principles and operations which a long and varied experience has shown to be needed and used repeatedly by beginners, school pupils, and amateurs. It is hoped that it will answer a large proportion of the common questions about the more important problems of general woodworking.

C. G. W.

ACKNOWLEDGMENT

ACKNOWLEDGMENT is due the following manufacturers for permission to use illustrations of some of their products: Henry Disston and Sons, Inc., Philadelphia; The Simonds Manufacturing Co. (Simonds Saw and Steel Co., Successor), Fitchburg, Mass.; The Stanley Rule and Level Plant, New Britain, Conn.; The Millers Falls Co., Millers Falls, Mass.; The L. S. Starrett Co., Athol, Mass.; The North Bros. Manufacturing Co., Philadelphia; The Cincinnati Tool Co., Cincinnati, Ohio; The Morse Twist Drill and Machine Co., New Bedford, Mass.; The Syracuse Twist Drill Co., Syracuse, N. Y.; The Russell Jennings Manufacturing Co., Chester, Conn.; E. H. Sheldon and Co., Muskegon, Mich.; The Batavia Clamp Co., Batavia, N. Y.; The Adjustable Clamp Co., Chicago; The Pike Manufacturing Co., Pike, N. H.; The Stine Screw Holes Co., Waterbury, Conn. Also to Hammacher, Schlemmer and Co. Inc., New York, for the use of illustrations from their catalogue, and to the Forest Products Laboratory, Madison, Wisconsin, for valuable information.

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Acknowledgment

Ill. Acknowledgment is especially due Mr. Percival White of New York for much valuable advice and help.[1]

[1] Some of the illustrations for which acknowledgment is made above, do not bear the names of the makers. They are therefore specified here: The Stanley Rule and Level Plant, trammel, p. 20, smoothing plane and router, p. 61, blind-nail tool, p. 93, dowel cutter and sharpener, pp. 333, 334; Henry Disston and Sons, Inc., and The Simonds Manufacturing Co. for cuts of saw teeth, pp. 47–48, 51–52, 120; E. H. Sheldon and Co., bench stops, p. 3; The Russell Jennings Manufacturing Co., screw points (bits), p. 75; The Cincinnati Tool Co., screw and plug bit and plug cutter, p. 83, clamp, p. 102; Batavia Clamp Co., clamps, p. 102; Hammacher, Schlemmer and Co., Inc., corrugated fasteners, p. 90; The Stines Screw Holes Co., screw holes, p. 100; The Adjustable Clamp Co., Jorgensen clamps, p. 108; The Pike Manufacturing Co., whetting, pp. 114, 115; Baxter D. Whitney and Son, Inc., circular saw bench, p. 274, planer, p. 298, cutter head, etc., p. 299, boring machine, p. 312, shaper, p. 333, scraper and toothing knife, p. 334; The American Wood Working Machinery Co., sawing segments, p. 288, jointer, pp. 301, 303, 305, 306, sanders, pp. 308, 309; The Oliver Machinery Co., swing saw, pp. 290, 291, portable band saw, p. 292, jig saw, p. 296, mortising machine, p. 330; The Mattison Machine Works, belt sander, p. 310; The J. A. Fay and Egan Co., trimmer, p. 74, safety guards, pp. 275, 303, 312; The W. F. and John Barnes Co., jig saw, p. 297.

SUGGESTED BOOKS FOR READING

Among many books to which the reader might be referred for special study, a few may be mentioned here: *Carpentry*, by Griffith, Manual Arts Press; *Wood and Forest*, by Noyes, Manual Arts Press; *Lumber and its Uses*, by Kellogg, U. P. C. Book Co.; *Glues and Glue Handling*, by Teesdale and Bezeau, Periodical Publishing Co.; *Problems of the Finishing Room*, by Schmidt, Periodical Publishing Co.; *Wood Turning*, by Ross, Ginn and Co.; *Art and Education in Wood Turning*, by Klenke, Manual Arts Press; *Wood Pattern Making* by Purfield, Manual Arts Press; *Mechanical Drawing*, by Ermeling, Fischer, and Greene, Bruce Publishing Co.; *Problems in Mechanical Drawing*, by Bennett, Manual Arts Press; *Mechanical Drawing Problems*, by Berg and Kronquist, Manual Arts Press; *Mechanical Drawing for High Schools*, by French and Svenson, McGraw-Hill Book Company, Inc.; *Blue Print Reading*, by Wyatt, Bruce Publishing Co.; *Furniture Upholstery*, by Johnson, Manual Arts Press. Interesting and valuable information may be found in the educational pamphlets, charts, etc., issued by Henry Disston and Sons, Inc., the Simonds Tool and Steel Co., the American Wood Working Machinery Co., the Pike Manufacturing Co., the Stanley Rule and Level Plant, and others. Also from the catalogues issued by various manufacturers, and those of dealers, as Hammacher, Schlemmer, and Co. of New York.

TO TEACHERS

There is need of more concentration upon the *essentials of today*. Also, as President Sills of Bowdoin said recently, "there is too much teaching and not enough learning" nowadays.

The elementary principles of woodworking, as of other subjects, can be re-discovered by small children, to their advantage, whenever there are enough teachers capable of setting the stage for such investigative and inventive work and of seeing that the play is successfully carried out, and whenever the means and time are provided. At present, however, for most communities this is merely a pedagogical theory. When we come to the sixth, seventh, eighth grades, secondary schools, technical schools, and mature amateurs, it is too late to expect such pupils to re-discover for themselves or to learn wholly by experience such simple principles as this book contains.

The more quickly the pupil can learn these principles—as he needs them—the better he will get along with the real work itself, whatever it may be. He can learn these fundamentals readily with this manual at hand and the teacher be relieved of part of his routine work. No school workshop can be really successful unless the teacher is fresh enough to be on the *qui vive* mentally and on the jump physically all the time. The more he can be freed from routine duties the less likely he will be to go stale or become narrow; and the breadth and enthusiasm of the teacher react very powerfully upon the pupils,—for the old adage, "as is the teacher so is the school," still holds true.

If the inexperienced teacher thinks this book contains more than his classes need, he may be reminded that he is obliged to use no more than he requires and can leave the rest until wanted. Also, that it is a vital part of a shop teacher's work

to be a good sport,—to have such good relations with his pupils that they feel free to talk with him about their outside problems. The initiative, enquiring spirit, and capability of the ambitious pupil are not bounded by any school programme. Besides, increasing numbers of schools are reaching out after community work, work for the schools themselves, household work, etc. All these things, with the varied demands of emergencies, call for many, often unexpected, operations—whether the actual work be done in the school shop or outside. Just as the teacher is under a handicap if he does not know much more about his subjects than is contained in any ordinary "Course"—the pupils will quickly discover his limitations—so the ambitious pupil also is retarded if he does not have some readily available means of learning for himself about common principles and operations, whether included or not included in his regular school work. It is hoped that this book may thus help both the inexperienced teacher and his still more inexperienced pupils.

Looked at from the artistic or sentimental point of view there is something about hand work—the human touch or personal equation—which no machine can supply, as with carving, a piece of antique furniture, a colonial house; but we must accept the fact that we are now living in an age of automatic machinery. We may love a spirited horse, but we travel by motor. With the individual, however, and with the school, it is not yet necessary to sacrifice the advantages of hand work merely because it is wise to use machinery for some operations. While no one should be allowed to become an automaton from the continued employment of self-acting inventions, a reasonable use of the common machines calls for intelligence and is educative.

If one spends ten hours in doing by hand routine work which he has already learned to do reasonably well, when he can accomplish this work with a machine in half an hour, he is wasting valuable time. The judicious use of machinery,

either by the pupil or by others for him, greatly enlarges his opportunities, and machinery will not exhaust the possibilities of desirable hand work in wood for a long time to come.

We learn to a great extent by doing, by experiences. Therefore, for example, if one may have time to go through ten different experiences using hand work only, he may, with the help of machinery for common routine operations, go through perhaps fifty different experiences. The time thus saved by the use of machinery will allow him to advance to more difficult problems in woodworking, or to take up other desirable subjects, instead of being held back by doing over and over again what he has once learned. His acquaintance with work can thus be more varied and include also some of the elements of modern industrial methods; not to speak of producing more work, usually of better quality. Whether pupils can use, or should use, machinery must depend upon the conditions of each case, but all should know what the common machines do, how they work, and how to avoid injury from them.

This book contains no pedagogical theories. It is simply a working handbook for everyday service,—to be used according to the methods of each teacher and the conditions of each school. The ability to use tools properly is not the end and aim, nor the most vital part, of manual training, but an available working knowledge of fundamental principles and operations is essential to doing work that is worthwhile. Therefore it is hoped that whatever wasted energy this handbook may save will be devoted to those stimulating and developing projects of real life which are the soul of manual training—those undertakings which are so numerous that a long waiting-list can always be ahead of even the most wide-awake teacher and his pupils.

The inexperienced teacher who may make use of the Questions included in this book may be reminded that the *intelligent* performance of an operation is a better test of a pupil's mastery of the subject than the ability to make oral or written statements about it.

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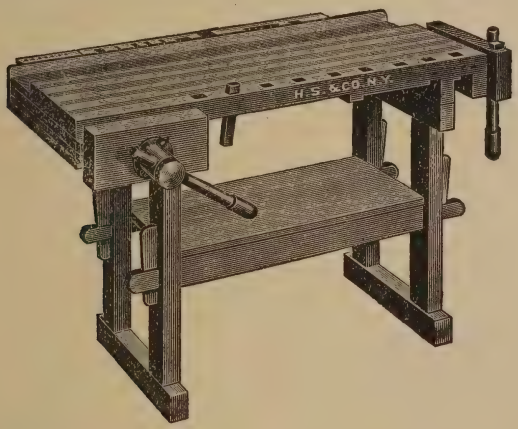
WOODWORKING

WORKSHOP, TOOLS, AND OTHER EQUIPMENT

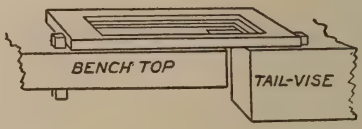
1. **A workshop** should be well lighted, dry, and have a good wooden floor. Place the bench so that you face the light when working, and also have light on your left if possible.



2. **Benches and vises.** Common form of school bench, excellent also for home use, with vise for holding wood at the left,[1] and tail-vise at the right end with stops (pegs) for holding

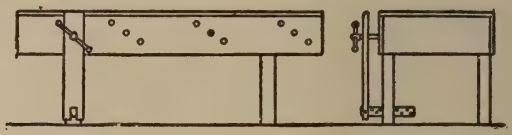
[1] When screwing the vise very tightly to hold a piece in one end only put a waste piece of the same thickness in the other end, to equalize the pressure (97). There are a number of desirable "quick-action" vises which can be adjusted readily to hold work in various positions.

work. There is a rack for tools at the back. A cabinet-maker's bench is similar but larger.[1] There are many kinds of benches. The frame should be firmly bolted together or keyed, as shown, and the top prevented from warping by being made of selected strips (534) of maple, beech, birch, or other fine-grained hard wood, glued, bolted together, and sometimes dovetailed (527). Have the bench firmly fastened to the floor.



3. **Showing use of stops.** The work is held between a stop in the tail-vise and a stop in one of the holes in the bench top.

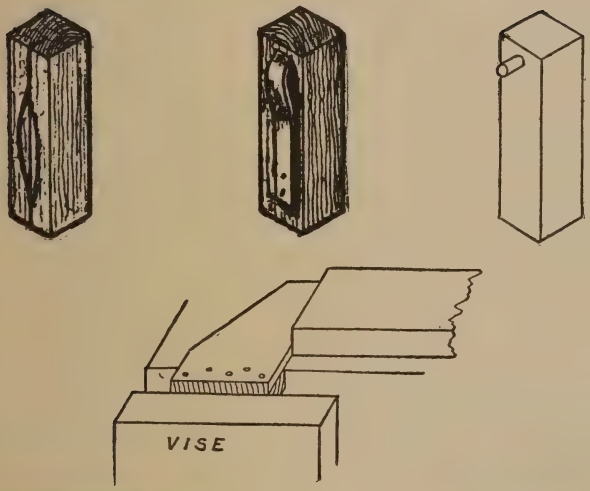
4. **Common carpenter's bench,** usually made of soft wood, with iron vise-screw, and often an adjustable iron bench-stop



or dog (6) at the left end of the top to hold boards while planing the sides. The holes in the front are for pegs to support long boards when on edge in the vise. Such a bench will do for much common work. Boards running lengthways can be used for the top, but a thicker top of plank is better.

[1] The height of a bench should be such that the worker's right elbow, when holding the plane, will be slightly bent and his back about straight. A bench for cabinet-making or pattern-making is usually a little higher than one for carpentry, while a carver's bench is a little higher still. A nice bench top should be scraped occasionally (194), rubbed with linseed oil, and given a coat of shellac (406).

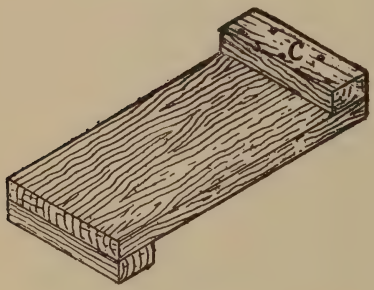
5. **Showing arrangement of vise.**

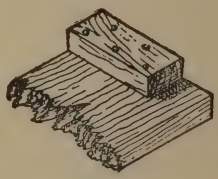


6. **Bench stops.** There are many kinds.

7. **Simple devices for holding stock** on a rough bench.

8. **Bench hook.** Useful for holding work on the bench for sawing, planing, etc. About 15″ long by 6″ wide is a good size. The cross cleats should be square with the right hand





edge of the board. The under cross cleat can be pushed against the front edge of the bench or fastened in the vise. Hold the work against the upper cross cleat C (122). If this cleat be short, it may save marring the bench when sawing.

9. Horses for sawing and for supporting work. The height should be such that you can work conveniently,—from 18″ to a little over two feet.

10. Tools. The most important thing with edged tools, hammers, etc., is the quality and proper tempering of the steel. It is best not to buy cheap tools.

It is impossible to make a satisfactory list of tools for everyone, because there is practically no limit to the variety of work which an amateur or beginner may have good reason for undertaking. The assortment found in school shops is usually greater than the beginner needs at first for home work. The wisest way is to begin with a few of the most common tools, adding others as they are needed. Refer to the manufacturers' catalogues. A great deal of ordinary work can be done with only a *rule*, a *try square*, a *cross-cut saw*, a *jack plane*, a *hammer*, a *bit brace* and a few *bits* and *drills*, a *screw driver*, and one or two *chisels* (¼″, ½″, 1″). If your work is at all varied, however, you cannot get along to good advantage without a larger kit, including for example: a *rule*, a *try square*, a *straight-edge*, a *knife*, two or three *chisels*, a *hatchet*, a *gauge*, a *plane*, a *spokeshave*, a *cross-cut saw*, a *hammer* and *nail set*, a *bit brace* and several *bits* (twist bits and drills are good for the smaller sizes), a *countersink*, a *screwdriver*, a *rasp* and half-round *file* for wood, an *oilstone*, a *glue-pot*. When you feel the need of more tools you will wish to add, perhaps, one or two more *planes*, a *rip saw*, one or more *gouges*, a *mallet*, a *back saw*, *compasses*, a *steel square*, a *drawknife*, one or two more *screw-drivers*, a *scraper*, a few *hand screws* or *clamps*, a few more *bits* or some kind of automatic borer, a *level*, a *bevel*, a *grinding wheel*, etc. These are merely suggestions as to the best way

to acquire a set of tools. It all depends on the work you do. For example, you can do a great variety of work without needing a level or plumb. On the other hand you may need these quite often. Therefore it is well to defer buying tools having limited uses until you need them.[1] Good sets of tools are put up by a number of reliable makers and dealers, but avoid cheap sets of the toy class.

Keep all common everyday tools within convenient reach. To prevent rusting, rub with sperm oil or other anti-rust substance. Burn oily rags to prevent spontaneous combustion. Keep bandages and a few remedies for accidents at hand.

11. **Fitting handles.** Where the handle goes through an eye, as with the hammer, axe, etc., shape the handle to fit, split or saw into the end, on the long diameter, and fit and drive in a wedge, or wedges, until the end is spread to fit very tightly. Then smooth the end. Other wedges are often driven crossways of the end. Metal wedges and other tightening devices are also used. With a tool like a "tang"[2] chisel (**83,** footnote) bore a hole in the handle slightly smaller than the tang, insert end of tang, and strike the end of the handle until the tool and handle are fitted. A broken handle can be removed easily from a hammer head by placing in an oven with moderate heat.

QUESTIONS

1. *What conditions are essential for a good shop?*
2. *What is the most important requirement in placing the bench?*
3. *How should the top of a good bench be made? Why?*
4. *Show how to hold work with a temporary or rough bench.*
5. *Show the use of a bench hook.*
6. *What is the most important requirement for edged tools?*
7. *What tools would you buy first in gradually acquiring a set?*

[1] Besides woodworking tools the worker in wood often has use also for such tools as an anvil with flat top and "round horn" or conical point (a heavy piece of iron is better than nothing), a vise for metal (on a separate bench), pliers, cutting nippers, cold chisel, hack saw, snips for metal, files for metal (flat, triangular, and round), monkey wrench, Stillson or pipe wrench, wrecking tool, etc.

[2] The tang is the pointed end to be driven into the handle.

TOOLS FOR LAYING OUT AND TESTING WORK

12. Common tools are the Rule, Steel tape, Square, Knife, Scratch-awl, Pencil, Bevel, Marking-gauge, Compasses or Dividers, Straight-edge, Chalk and line, Level, Plumb, and Calipers.

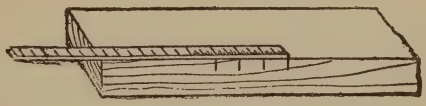
Measuring, marking, and testing must be *accurate* or the rest of your labour may be wasted. In common work where many pieces of the same length are to be cut, use the first piece cut as a measure for all the rest.

13. Marking. For fine work, mark with a knife[1] or sharp pencil. For rough work, use a scratch-awl (with a sharp point) or a carpenter's pencil (with a wide lead). The knife should be sharp but should not have a very thin point. Sharpen pencil points on sandpaper or a fine file.

Rule

14. Measuring and marking dimensions. Lay the rule on edge so that the divisions on its side touch the wood.[2] Mark

ACCURATE

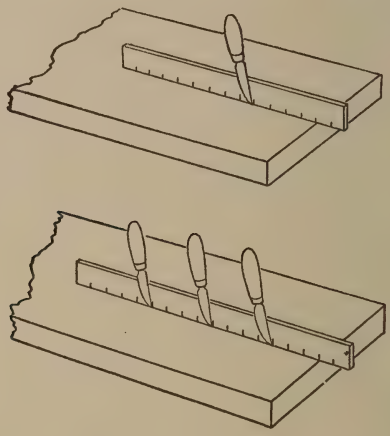


INACCURATE

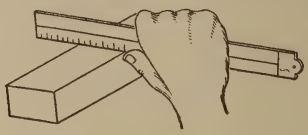
[1] The corner of a chisel can be used, drawing the edge toward you, as you would a knife, keeping the nearer corner of the chisel edge raised above the wood. The flat side of the chisel should be against the edge by which you are marking.

[2] This does not apply to a rule with the scale on a bevelled edge.

with a knife or sharp pencil. Mark a series of short distances without moving the rule, for every time you set it you are



likely to make a slight mistake, which will affect each remaining measurement and the total measurement.



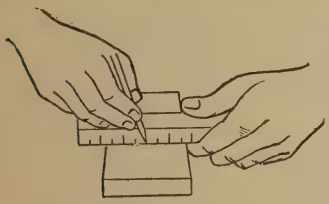
15. Making a short measurement. Use any divisions on the rule rather than the end, for the end is likely to be inaccurate and is hard to place on the line or edge.

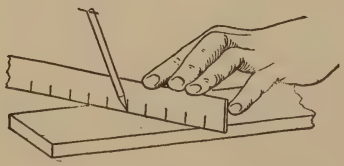
16. For long distances mark on a stick or use a steel tape. Marking on a stick is a good way to transfer short measurements also. To make an exact long measurement you can use two rules, placing the second at the end of the first, then the first at the end of the second, and so on. The zigzag folding rule, from 2′ to 8′ long, is convenient. With a sliding extension it can be used for inside measurements (**17**). To verify a measurement, measure back to the starting point. For large rough work have a 10′ or 12′ rod with feet and inches marked.

17. Inside measurement. To find the distance between two points where it is hard to use a common rule, take an

extension- or slide-rule, or two sticks as shown. For example, when fitting an upright post between floor and ceiling in the middle of a room. See *Calipers*, **44**.

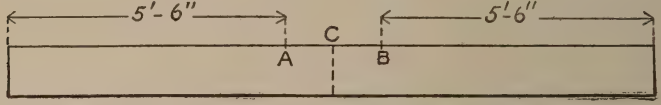
18. Dividing the width of a board into two or more equal parts quickly. To find the middle, set the rule so that some inch-mark is equally distant from each edge. In the first illustration, the inch-mark shown by the pencil point is $1\frac{3}{4}''$





from each edge. Or the rule can be turned slantingly, as in the second illustration, and the distance divided into a number of equal parts quickly. If set, for example, to measure 6″ from edge to edge, the width can be divided readily into halves, thirds, quarters, sixths, twelfths, etc. See also *Compasses*, **42**.

19. Finding the middle of the length of a board or other long surface. Measure from one end to as near the middle as

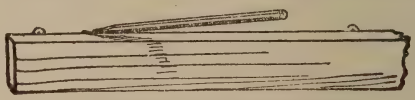


you can judge by eye and make a mark (A). Measure the same distance from the other end and make another mark (B). The distance between A and B, being short, can be halved quickly.

Straight-edge

20. Straight-edge. This can be anything with a straight edge, from a common ruler or the blade of a square to a long board. Used to mark straight lines and to test edges for straightness and broad surfaces for flatness (**57, 62,** etc.).

21. Marking by a straight-edge. Keep the top of the marking tool slightly inclined away from the straight-edge,



THICK RULE—ROUGH WORK

but with the point close to it. Have one or two long straight-edges on hand.[1] For testing work, see **52,** etc.

[1] A wooden straight-edge should be made of wood which will keep its shape. Quarter-sawed (**739**), thoroughly seasoned white pine, or mahogany, is good.

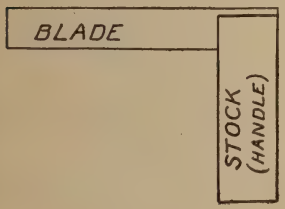
THIN RULE—FINE WORK

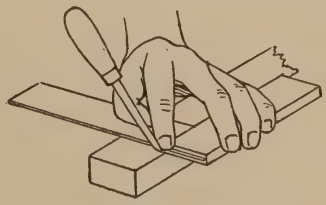
For very fine pencil or ink work, like drawing, with a thin straight-edge, as a tee-square, ruler, or triangle, place the edge not quite on the points for the line, and tip the marking tool the opposite way, as shown.

To test a straight-edge, mark a fine line by it, then turn it over, but not end for end, and see whether the edge coincides with the line. Test a short edge by placing on a surface known to be flat, like an iron saw-bench top.

Square

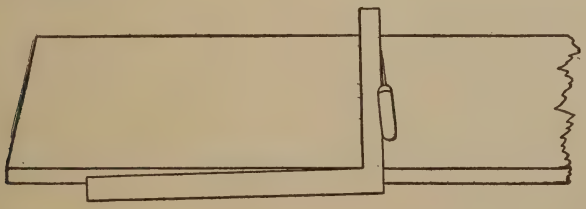
22. Square. Used to mark lines at right angles to an edge or surface, and to test right-angled work. The common forms are the *Try square* and the *Steel square* or *Framing square.*





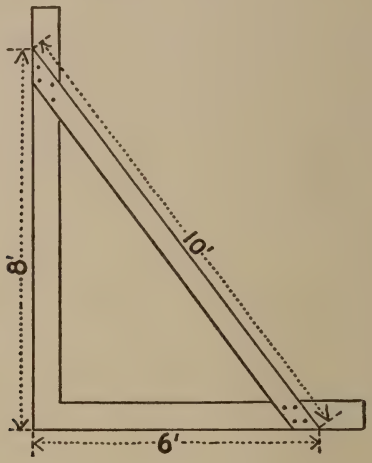
23. Squaring a line across the grain with Try square. Select one edge from which to square all lines, for the edges may not be parallel. For nice work this edge must be straight. *Press the stock of the square against the wood* and mark along the blade with a knife or sharp pencil. A good way is to place the knife where the line is to be marked, and slide the square along until it hits it. Then mark the line. To mark lines with the grain (**292,** etc.), use the gauge (**28**). For testing work with square, see **58,** etc.

24. Steel square or Framing square. Chiefly used in building construction, but also in shops for large work. Many computations can be made and much laying out of work done with it. The blade (the long arm) is 2″ wide and the tongue (the short arm) is 1½″ wide. See also **35, 36.** See *The Steel Square*, Hodgson.



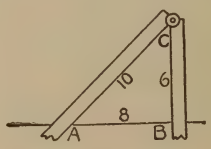
25. Squaring a line with Steel square.

26. Mason's square. For large work, like squaring foundations, sills, etc., make a square of narrow boards. Any



triangle with sides three, four, and five units in length (or any multiple of these units, as six, eight, and ten) can be used as a square.[1]

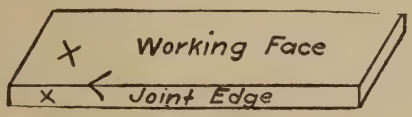
[1] This is on the mathematical principle that in a right-angled triangle the square of the hypothenuse is equal to the sum of the squares of the other sides. $5 \times 5 = 25$. $4 \times 4 = 16$. $3 \times 3 = 9$. $25 = 16 + 9$.



On the same principle, in an emergency, if you have only a common two-foot rule, lay off 8″ (AB), partially open the rule, place it so that the division 6″ from the hinge on one arm of the rule and that 10″ from the hinge on the other arm touch the ends of the 8″ line at A and B. Draw line CB. It will be at right angles to AB. For larger work, in an emergency, two

Face-Side and Joint-Edge

27. Working-face or face-side and **Joint-edge** or working-edge. First select one edge (usually the better edge) of the board or plank, mark it, and use the square from this edge



only, for the edges may not be parallel. This edge is often called the "joint-edge" or "working-edge." If not straight and square, plane it until it is so (**138,** etc.), for you must have *at least one accurate edge* from which to lay out work properly. In the same way when squaring lines across the edges of a board or plank, select one side (usually the better side), mark it and square from this side only. (Often called the "working-face" or "face-side.") A mark like a V will show both joint-edge and working-face. See also **72, 296,** etc.

Gauge

28. Gauge. Used to mark lines parallel with an edge, with the grain.

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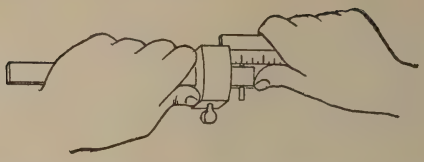
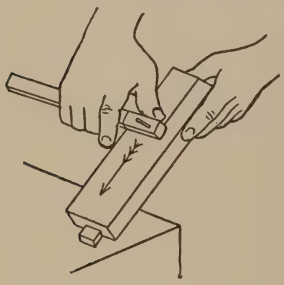
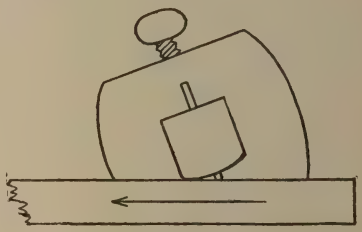
straight-edged strips can be placed approximately at right angles, by eye, and then adjusted by measuring on the principle just shown, until the edges are at right angles. A right angle can also be found by *carefully* folding a sheet of stiff paper,—once if it has a straight edge, twice if it has not; and the result will usually be as accurate as the work of any but a highly skilled workman. Such methods are for emergencies only, not for use in a well-equipped shop. No good workman would use such a method as folding paper if a regular square were available, but much work often has to be done in places where the proper tools are not within reach. If the right tool cannot be found the capable and resourceful workman contrives a substitute.



29. Setting the marking gauge. Have the spur project only from $\frac{1}{16}''$ to $\frac{3}{16}''$. Set it at the required distance from the head. If the tool is in good condition, set it by the scale on the bar. If not, and for accurate work, measure with the rule as shown.[1]

30. Marking with gauge. Hold the wood firmly against some fixed object, or in the vise, or otherwise. Hold the gauge as shown. Press the head of it against the edge of the wood.





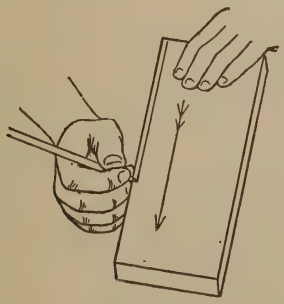
Turn it slightly from you, so that the spur will be *drawn* along, and push the tool steadily from you as far as the line is to be marked. Keep the head pressed against the wood, for the spur is apt to follow the grain. When gauging parallel lines, gauge all from the same edge or side, for the edges or sides may

[1] The spur will make a better line when slightly convex on the side toward the head and with the front corner slightly rounded.

not be parallel. To mark across the grain, use square and knife or pencil (**23, 24, 25**).

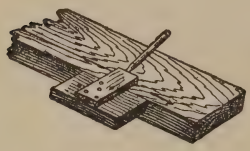
A *mortise gauge* has two spurs. A metal *roller gauge*, has a roller instead of a spur. This can be used across the grain for ordinary work. Both rollers can be used for mortising (**467**), etc. There are other gauges for special uses, as for very wide stock, for cutting thin stock, for fitting hinges, etc. If gauge-marks would deface the work, use a pencil-gauge, or make one by boring a hole for a pencil near one end of the bar of a wooden gauge. The Try square can be used as a gauge, if necessary, with the graduations on its blade. See *Combination square* (**37**).

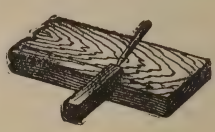
31. **Thumb-gauging, for rough work.** Slide rule and pencil along together, guided by thumb or finger at the edge.

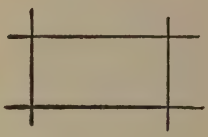


32. **Gauging near an edge with finger and pencil.** A good way when scratches would deface the work and when exact

measurement is not needed. For example, when rounding the edge of a board, such lines show where to stop the rounding, and the surface will not show gauge marks.





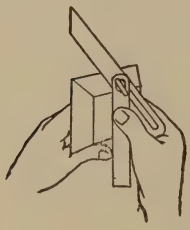


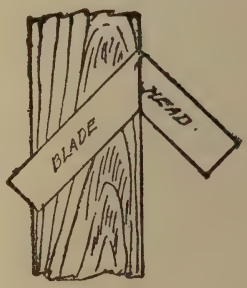
33. Emergency gauges. Easily made and also convenient for special work to save re-setting the regular gauge.

Intersection of lines. When gauge lines meet other lines, let them run by if the marks will not deface the work, for the crossing of two lines is the best way to mark a point.

Bevel

34. Bevel. For marking or testing any angle except a right angle. Set the movable blade of the T-bevel at the

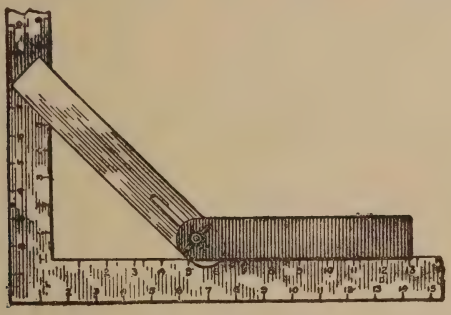




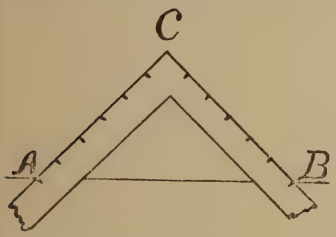
angle you wish, and use like the square. In the same way test or duplicate an angle. The *Mitre square* is accurate for small work only.

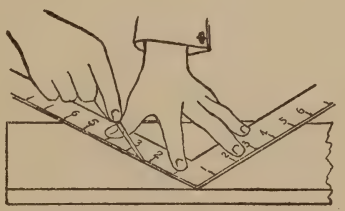
35. Setting bevel at 45°. Place on the edge of the steel square and set the blade of the bevel at the same division on

both the blade and the tongue of the square. In the case shown, the bevel is set at 5″ on the tongue of the square and at

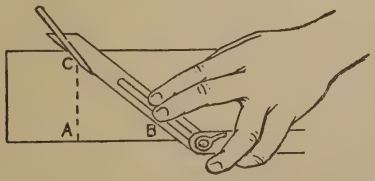


5″ on the blade. For other angles note the figures intercepted by the blade. See *Mitre-box* (**128,** etc.), *Mitring* (**508,** etc.).





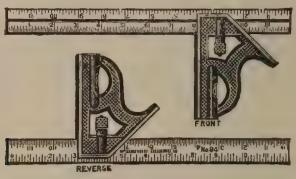
36. To mark an angle of 45° on the wood with the steel square, place the same divisions on the blade and on the tongue at the edge of the board. In the case shown, 6″ on each. The lines AC and BC will be at 45° with the edge of the board.[1] This is often simpler than to use the bevel. An angle of 45° can be tested in the same way.



[1] If you have no steel square, a right angle can be drawn from the straight edge of a board, points B and C marked at equal distances from

Combination Square

37. Combination square. Combines marking gauge, square, rule, mitre square, depth gauge, height gauge, level,



and plumb. For common work a combination tool called "*Odd jobs*" is useful.

Compasses or Dividers

38. Compasses or Dividers. Used to describe or "strike" circles or arcs; to take measurements from a rule, a drawing, or some object; to lay out measurements; to divide distances; to "scribe," where a gauge cannot be used (See *Scribing*, **571**); to lay off angles and arcs.

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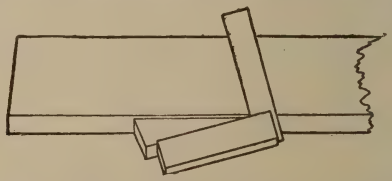
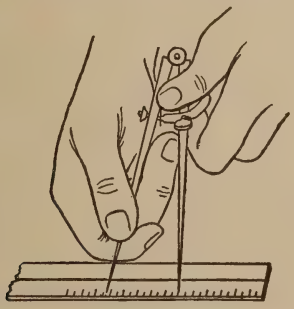
the point A, and the bevel set at 45° by the points B and C, or the angle can be drawn directly on the wood. The bevel can also be set at different angles from a protractor or from a drawing triangle, etc. Any angle can be marked by cutting a wedge-shaped piece with the required taper and

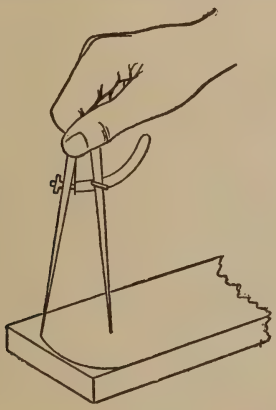


holding it against the inside edge of a square. The square used in the ordinary way will then give the required bevel, as shown. An emergency bevel can easily be made by nailing together two sticks of wood at the required angle, and is sometimes convenient to save resetting the regular bevel. Stiff paper can also be folded (see **26**, footnote).

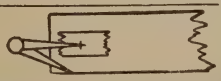
39. Setting by the rule. The set-screw at the side of the curved wing fastens the legs wherever you wish. Adjust the points accurately with the nut and spring.



40. To mark circles or arcs of circles. Set the compasses (39) so that the distance between the points is equal to the

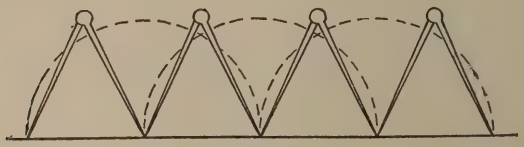


radius of the circle or arc. Place one point at the center, hold the compasses lightly at the top and lean them slightly in the direction they are to be turned. Then draw the curve.[1]



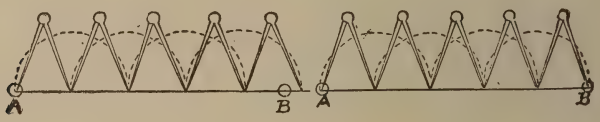
[1] A thin slip placed under the point at the centre will save defacing the surface. When a scratched curve would be objectionable, use pencil dividers or a pencil attachment.

41. **"Stepping off" with compasses.** To repeat a short measurement several times set the compasses at the required

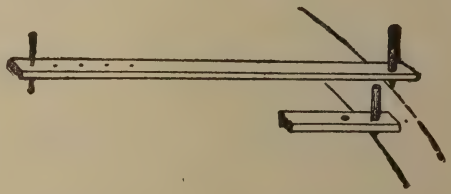


distance (39), and "step off" the measurements by turning the compasses first upon one point and then upon the other, but without pressing the points into the wood more than to make a visible dot.

42. **To divide a short distance,** as AB, into any number of equal parts,—five, for example. Set the compasses at one-fifth of the distance, as nearly as you can judge by eye, and



step them over the space (41). Open or shut them one-fifth of the distance by which they overrun the point B or fall short of it, as nearly as you can estimate by eye, and step over the space again. When right, press the points into the wood only enough to make a visible dot.

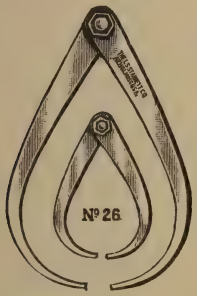


43. **Trammel points,** sliding on a bar, for large circles or arcs. A pencil point can be used. There are similar attachments for a rule. In an emergency use a stick, or strip of any

firm material, and two nails, or one nail and a pencil, as shown.[1]

Calipers

44. Calipers are for measuring diameters. To read the measurement apply the calipers to the rule. They can also be

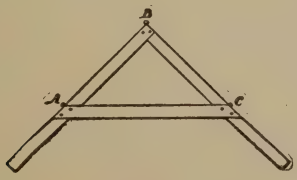


OUTSIDE CALIPERS

INSIDE CALIPERS

set by the rule. "Outside" calipers find the outside diameter (**681**). "Inside" calipers measure the distance between two inside points, as the inside diameter of a pipe, etc. For large

[1] To draw a circular arc when the centre is out of reach. Suppose the arc is to pass through the points A and C. Drive nails at A and C, make a



triangular frame of strips with a right angle at B, and slide it around with a pencil or marking point at B, keeping the frame pressed against the nails as it is moved. The pencil will describe the required arc. For smaller work slide the steel square around in the same way (**701**, footnote). These methods are often useful where extreme accuracy is not required.

work, see **17**. Some rules have caliper adjustments for small work.[1]

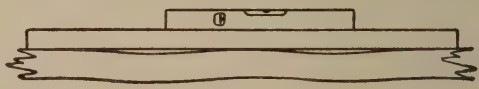
Spline

45. Spline. Drawing an irregular curve. Drive a nail, fasten a clamp, or place a weight, at each end of the desired

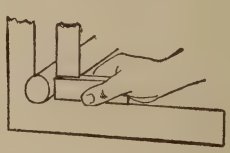
curve. Push a flexible strip or spline against the nails, bend to the required curve, and draw the line.

Level and Plumb

46. Spirit Level (usually combined with a **Plumb**). This is used to tell whether a surface is level. Place the level, with glass bulb uppermost, on the surface to be tested. The glass



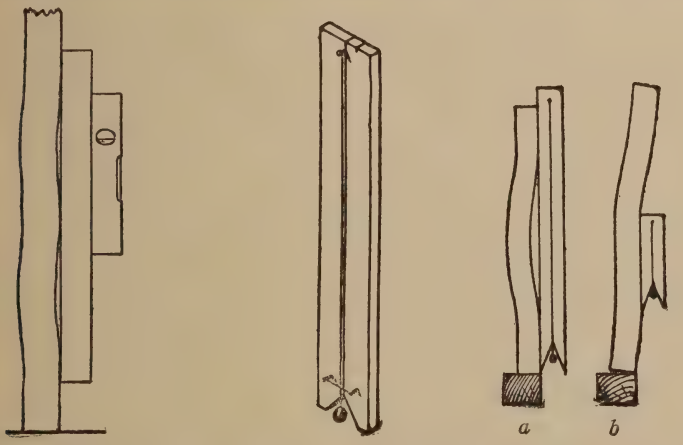
bulb has a mark in the middle and contains an air bubble. When the mark on the bulb is in the middle of the air bubble, the surface is level. On a long surface, place a long straight-edge (**20**) of uniform thickness under the level.[2]



[1] Outside diameters can sometimes be found with two squares. Read the scale on the edge of the outer square or measure the distance between the blades with the rule.

[2] Home-made level, several feet long, for rough work. When the plumb *ab* is vertical (on the line drawn from *a* to *b*), cd, at right angles to *ab*, will

47. Plumb. To tell whether a surface is vertical, place the level or plumb upright against the surface to be tested. When



the mark on the bulb near the top is in the middle of the air bubble, the surface is vertical. If the surface be long, place a long straight-edge of uniform thickness between it and the plumb.[1]

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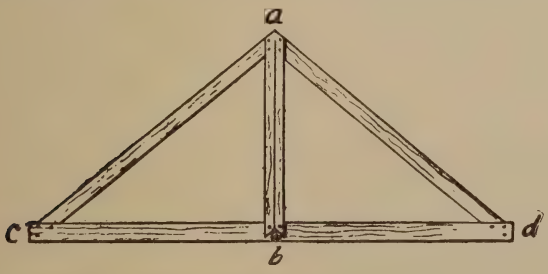
be level, because a level or horizontal line is at right angles to a vertical one. An approximate level can be found by using the steel-square (for which



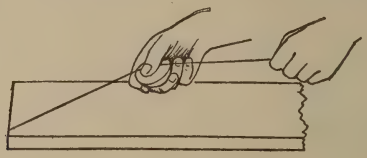
there is also a levelling attachment) or the larger mason's square (26) in a similar way. An emergency level for rough work can be found by filling a wide pan with water.

[1] Emergency plumb, made with a board, a weight, and a string, is fairly accurate if long, as at *a*. If short, it may be inaccurate for the whole sur-

48. **Plumb-bob.** To find a vertical *line* hang a weight by a cord. The cord will be vertical as soon as it stops swinging. To find a *point* vertically above or below another point, as, for example, to mark a point on the ceiling in a vertical line above a point on the floor, or *vice versa*, hang a plumb-bob by a cord.

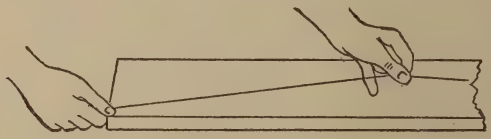
Chalk and Line

49. **Chalk and line.** Used for marking long straight lines, as for shingling. Drive an awl or nail at one end of the line



to be marked and loop around it the end of the cord. Chalk the cord from this end. The chalk can be revolved in the hand so that it will not be cut in two.

50. **Snapping the line.** Draw the cord taut at the free end, hold this end down with one hand, lift the line squarely from as



near the middle as practicable with thumb and forefinger of the other hand, and let it snap back to the surface. This will make a straight chalked line on the surface.

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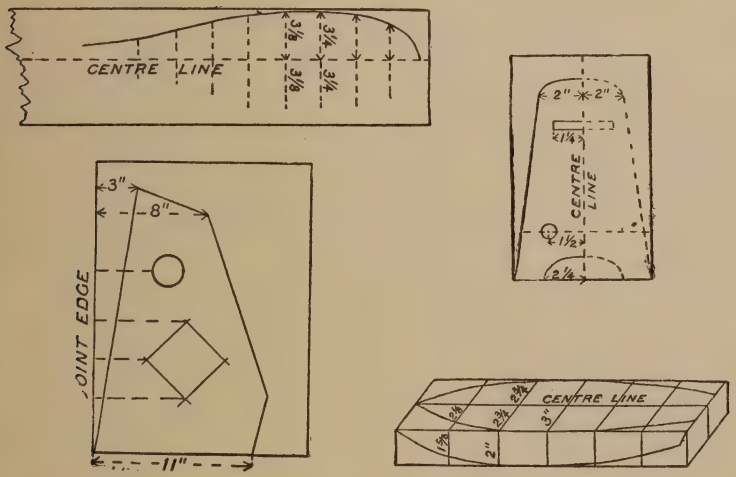
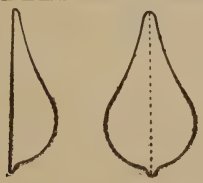
face, as at *b*. When cord hangs on center line or at apex of notch, the edge of the board, which must be parallel to the line, will be vertical.

Symmetrical Work

51. Symmetrical work can be laid out from a centre line or from the joint-edge (**27**). For example, the blade of a paddle. Square lines across the surface. Mark equal dis-



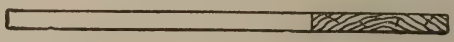
tances on each side of centre line and connect these points free hand, or with a spline (**45**); or draw on paper and transfer to the wood. In some cases, mark and measure from the joint-edge, as shown.[1]



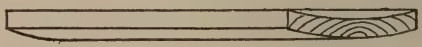
[1] Paper can often be used. Fold in the middle, draw one-half pattern, unfold and trace, or cut outline and mark by it. If a curved pattern is to be sawed, one-half can sometimes be drawn on the wood, and sawed carefully to the centre line, the waste piece turned over to the other side of the centre line and used to mark the duplicate half of the pattern.

Testing Work

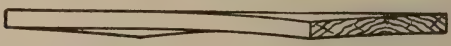
52. Testing work for squareness, straightness, flatness and symmetry. Keep testing. Test first by eye. When you cannot tell by eye, use testing tools.



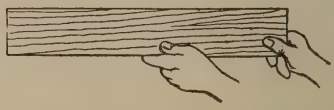
53. A flat surface. A surface is flat or true (a plane surface) when a straight-edge, in whatever position placed, will touch it throughout.



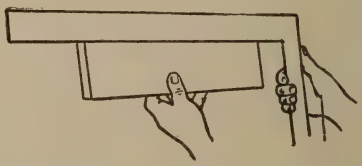
54. A curled or " cupped " surface.



55. A warped and winding surface (twisted).

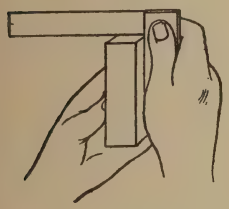


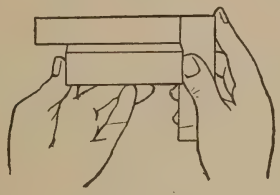
56. Testing straightness by eye. Face the light. Sight along the edge lengthways.

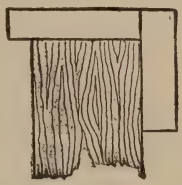


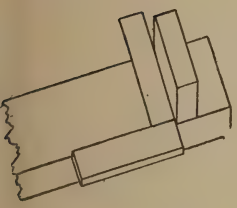
57. Testing short piece with straight-edge (20). Face the light. The edge can also be laid on a surface known to be flat, as the top of an iron saw-bench.

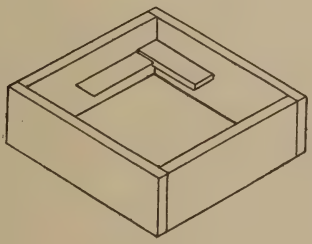
58. Testing for squareness. First test by eye, as for straightness (**56**). If you cannot tell by eye, press the try square against the wood, face the light, and see whether the wood fits the square. Test at several points. For large work use the steel square (**24**).

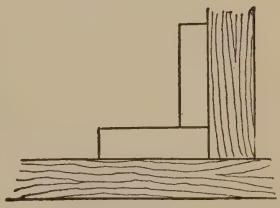






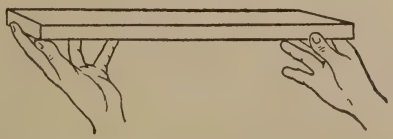






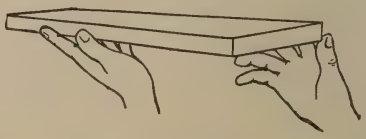
For some work the wood need not be flat. Sometimes, if warped or winding, it will be sufficiently flattened by being fastened into place. But for much nice work the surfaces must be flat in order that the parts may fit together properly, and for appearance.

Flatness and smoothness are not the same. A surface may be smooth without being flat. *To test the smoothness* run your fingers lightly over the surface.



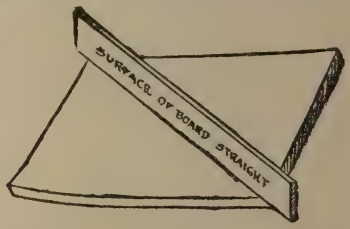
59. Testing flatness by eye. Sight across the surface toward the light.

60. **Testing flatness by eye.** Sight lengthways toward the light.

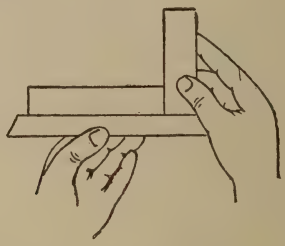


61. **Testing flatness by sighting diagonally.**

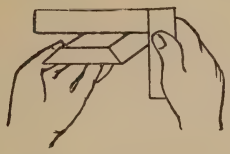
62. **Testing flatness with straight-edge.** When you cannot tell by eye, use a straight-edge placed in different positions.



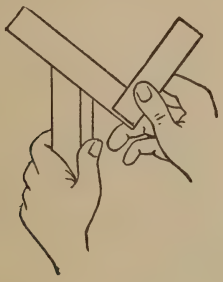
If it touches throughout, in all positions, the surface is flat. Face the light. The surface shown above is flat at one diagonal but not at the other.



63. **Testing flatness of small surface lengthways with square.**

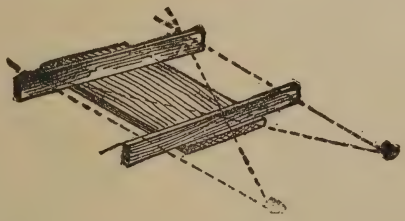


64. Testing flatness crossways with square.



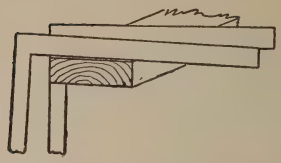
65. Testing flatness of edge with square.

66. Winding-sticks. To test large work, take two straight-edges (winding-sticks) each of equal width throughout, and

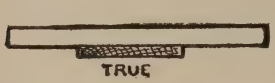


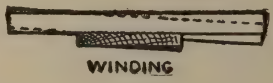
lay them on edge, one across each end of the surface to be tested. Then stand back and sight across the top edge of one straight-edge to the top edge of the other. If they are in line, there is no winding where they are placed. Test in different positions.[1]

[1] Making a four-legged object stand evenly. To find which leg, or legs, to cut to make a table or other four-legged object stand evenly, turn it over and use straight-edges on the principle just shown (**66, 67, 68**). Another



67. Steel squares used as winding sticks. The top edges of these squares are not in line, which shows this surface to be winding.





68. Long winding-sticks are best.

69. Testing angles of 45°, or any angle other than a right angle, can be done with the bevel used in the same way as the square, or by the steel square, etc. See **35, 36, 37.**

Laying Out Work

70. Duplicate parts should be laid out together if possible. Use a square to get the ends in line. Mark all together. If

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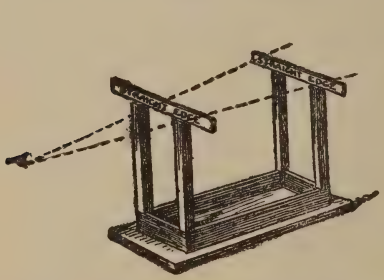
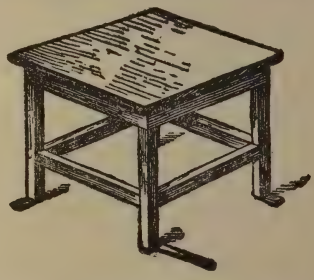
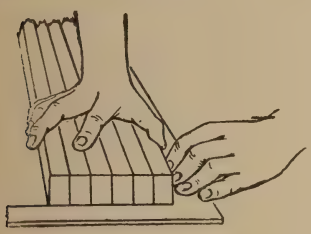
method. Place on a flat surface, wedge under the legs until the corners of the top are equally distant from the flat surface on which the object

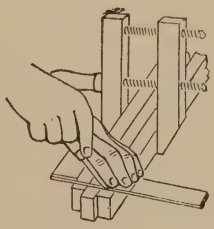


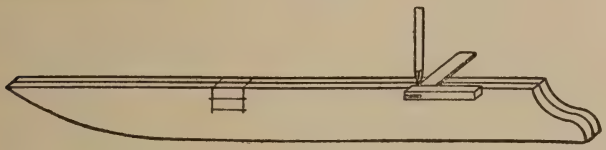


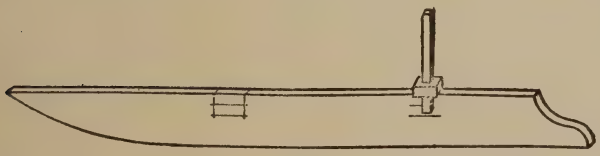
stands. Set the compasses (**39**) at the distance to which the shortest leg is raised, and scribe (**571**) around the other legs. Then cut them off. Or mark around the legs by using a strip or rule laid on the surface on which the object stands.

awkward to hold, use hand screws, clamp, or vise. Also gauge similar marks before re-setting gauge. Have the lines cross or

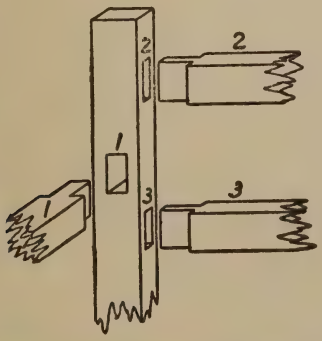








run by (33). On work which would be defaced by scratched lines use a pencil.



71. Marking position of parts. Where there is chance for mistakes in putting work together, mark the pieces and their

positions with figures, letters, or other symbols. When planning how work is to go together, it is well to mark roughly the places for joints, etc., before finally laying them out.

72. **Selection of face side and joint edge** (27). In some work the face side should be the side which shows, as the top of a table or the front of a picture frame; but the face sides of the legs of tables, chairs, etc., should be on the inside to ensure accurate joints with the rails (305) and other parts. The joint-edges of door-frames, etc., should be on the inside (372). All working-faces and joint-edges must be planed true where joints are formed. In some cases the joint-edge and working-face should be the poorer edge or face because the other will be more conspicuous.

73. **Expansion and contraction of the wood** must be allowed for when laying out many kinds of work (747, 326, 376, 379, 382 footnote, 387, 484, 541, etc.).

Summary. Accuracy essential. For fine work mark with a knife or sharp pencil. Start all measurements from the same edge, the same side, or the same point, when possible. Make lengthways measurements from one end, after that end has been squared. Make a single measurement when possible, rather than several successive shorter ones. Mark successive short measurements without moving the rule, when you can. Mark successive duplicate lengths from the piece first cut. Have accurate joint-edge or face-side from which to use square, gauge, bevel, or rule. Keep square, gauge, etc., pressed firmly against the wood. A point, or an angle, is best shown by intersecting lines. Do similar operations at the same time. Test repeatedly for accuracy (facing the light), first by eye, then with other testing instruments.

QUESTIONS

1. *What is most important in laying out and testing work?*
2. *What marking instrument should be used for fine work?—for rough work?*
3. *Show how to place the rule for accurate measuring or marking.*
4. *Why is it best to mark several short distances without moving the rule rather than to move it for each measurement?*

5. *What are the most accurate ways to measure long distances, or to transfer such measurements?*

6. *Show a simple way to find the exact distance from any point on a floor to the ceiling above, and in similar cases of inside measurements.*

7. *Show how to quickly divide the width of a board into two or more equal parts.*

8. *Show how to quickly find the middle of the length of a board or other surface.*

9. *If you are cutting fifty sticks of the same length, why should you use the stick first cut as a measure for all the rest rather than to use each stick as you cut it?*

10. *Find a straight-edge and show how to mark a line by it.*

11. *Show how to test the accuracy of a straight-edge.*

12. *What are the uses of the square?*

13. *Show how to square lines across the grain with the try-square—with the steel square.*

14. *Why, for accurate work, should you select one edge from which to square all lines? Why should that edge be straight?*

15. *Show how to make a mason's square, and give the mathematical principle upon which it is made.*

16. *Show how to use a common rule upon this principle.*

17. *Explain the terms working-face or face-side—joint-edge or working-edge.*

18. *Why select a face-side or a joint-edge?*

19. *In what cases should these be the better sides or edges, and when should they be the poorer ones? Why?*

20. *For what is the gauge used?*

21. *Show the proper projection of the spur, how to set the gauge, how to hold it, and how to mark a line with it.*

22. *If you are gauging two or more parallel lines, why should you gauge them from the same edge?*

23. *When is it better to use a pencil mark than the spur of a gauge?*

24. *Show how to "thumb-gauge." When is thumb-gauging desirable? Show how to gauge near an edge with finger and pencil. When desirable?*

25. *Show what the bevel is for, how to set it, and how to use it for marking or testing.*

26. *Set the bevel at 45° by the steel square.*

27. *Set it at 45° without the steel square.*

28. *Mark an angle of 45° directly on the wood with the steel square.*

29. *Show ways of marking at other angles.*

30. *Show how to set compasses or dividers by the rule, and to strike a circle or an arc.*

31. *How can you avoid scratching the wood?*

32. *How can you avoid pricking a hole at the centre?*

33. *Show how to "step off" a measurement several times.*

34. *Show how to divide a distance into a number of equal parts.*

35. *When would you use trammel points? Make a substitute.*

36. *Show how to draw a circular arc when the centre is out of reach.*

37. *Show how to find the diameter of a rod with calipers and how to read the measurement.*

38. *Show how to find the inside diameter of a pipe and how to read the measurement.*

39. *Show simple way to find outside diameter without calipers.*

40. *Show how to use a spline for drawing a curve.*

41. *Show how to use the spirit level—to level a long surface accurately.*

42. *Show how to tell whether a surface be vertical or plumb—to plumb a long surface accurately.*

43. *What is the simplest way to find a vertical line?*

44. *Show how to level approximately, without the spirit level.*

45. *If there is a hole in the ceiling of a room and you wish to bore a hole in the floor directly below, how can you find the point on the floor?*

46. *How can you make a plumb in an emergency?*

47. *Show how to use chalk and line.*

48. *Show different ways of laying out symmetrical curved work, like a paddle, model boat, etc.*

49. *What is the most important testing instrument—the one to use first?*

50. *From what direction should the light come?*

51. *Test the edge of a board for straightness:* (1) *by eye;* (2) *with straightedge.*

52. *Test an edge for squareness:* (1) *by eye;* (2) *with square.*

53. *Define a flat (plane or true) surface—a warped or winding surface —a curled or cupped surface.*

54. *Name a piece of work for which the wood must be flat—one for which it is not necessary that it be flat.*

55. *If the surface of a piece of wood be absolutely flat, mathematically speaking, must it also be smooth?*

56. *If it be practically flat, taken as a whole, must it also be smooth?*

57. *Is a smooth surface necessarily flat?*

58. *How do you test for smoothness?*

59. *Show how to test a surface for flatness.*

60. *Show how to use winding-sticks. Why are long ones better than short ones?*

61. *Show how to test the evenness of table legs and the like.*

62. *Show how to lay out and mark duplicate parts.*

63. *Why should you gauge or square similar marks at one operation?*

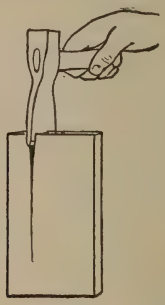
64. *If your work consists of a number of similar parts or of parts arranged in different ways, how can you avoid confusion and error in cutting, fitting, and assembling?*

65. *Mention any cases in which the expansion and contraction of the wood must be taken into consideration when laying out the work. Why?*

TOOLS FOR CUTTING, SHAPING, FITTING, ASSEMBLING, ETC.

74. Edged tools have a basil (bevel) on one side of the cutting edge or on both sides.

75. When a tool like the axe, hatchet, etc., which has a thick blade with a basil on each side of the edge, is used for



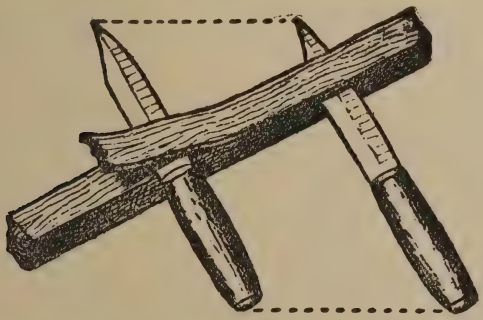
splitting, it acts like a wedge and forces the wood to split in advance of the cutting edge. Thus the edge cuts only when it first strikes the wood. See **578.**

76. Tools like the common chisel, drawknife, plane, etc., have a basil on only one side of the edge. When used for

paring and trimming, the edge cuts all the time and the basil bends the shaving out of the way. The common knife has a basil on each side, but as the blade is thin the shaving is bent

aside so that the edge cuts all the time when whittling. The carving chisel is thin, has two basils, and works in the same way. The edge of the axe or hatchet also cuts when used for light trimming.

77. A shearing cut. A cutting edge can be pushed straight ahead into the wood, or it can be drawn sideways as it is pushed forward. The edge of a razor can be pressed against the inside of the thumb without cutting, but if moved lengthways it will cut. Even a blade of grass will cut if drawn

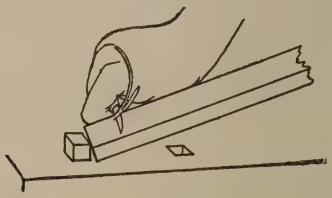


through the hand. A powerful magnifying glass will show that the edge of a sharp knife, for instance, is really quite rough and ragged, somewhat like a saw, and it will, as a rule, cut its way through the wood best if drawn lengthways, like a saw, at the same time that it is pushed forward. This is called a *shearing* cut. Usually the softer the material the greater the advantage. Owing to the angle at which it works, the cutting edge can also be considered as thinner, and so more effective, with a shearing stroke.

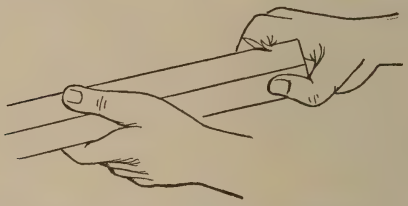
Knife

78. Knife. This tool should have a sharp point for marking when you lay out fine work (13). Face the light when whittling. Watch the grain carefully to prevent cutting the wrong way. Use a shearing stroke when you can, drawing

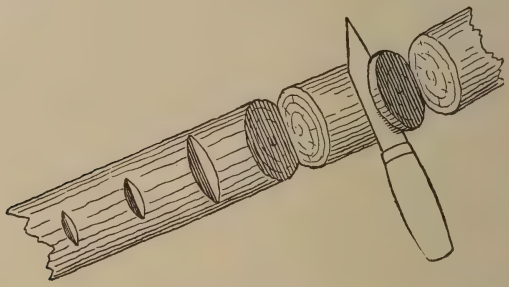
the whole length of the blade through the wood (**77**). In whittling a wide surface cut at the edges first. Keeping the arm which holds the wood against your body helps to steady the work. To sharpen, see **258.**



79. Wood pushed against a fixed object for steadiness.



80. Cutting toward thumb, but carrying the knife edge past thumb and not against it.



81. Cutting a notch. Begin in the middle and work outward.

Hatchet

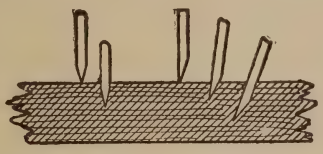
82. Hatchet. There are various kinds. Common uses are to trim wood roughly to shape, to remove waste wood, to

split, for shingling, etc. The hatchet, axe, etc., when used for paring or trimming, cut on the same principle as other cutting tools (**76**), but when used for splitting wood they act chiefly on the principle of the wedge (**75, 578**).

Chisel

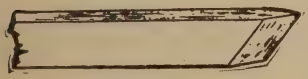
83. Chisel. The Firmer chisel (**89**) is usually sufficient for the beginner and amateur.[1] The secret in paring and trimming with the chisel is to push the tool with one hand on the handle and control the cutting with the other hand on the

[1] The *Firmer chisel* is for paring and trimming wood to shape and for light mortising (**467**). The *Framing chisel* is stouter, for framing, mortising, and other heavy work. The *Mortise chisel* is for heavy timber work. The *Paring chisel* is for paring only. A chisel for heavy work has the handle fitted into a socket on the blade. For light work a blade with a



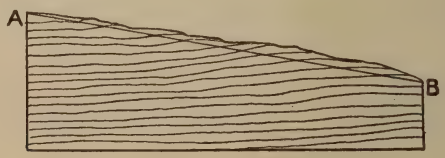
A B

tang which fits into the handle is common. The common chisel has a basil on one side only. The *Carving chisel* has a basil on each side. The latter cuts straight into the wood (A) because it has a basil on each side. The common chisel cuts in a curve (B)—cuts under, because it has a basil on one side only.



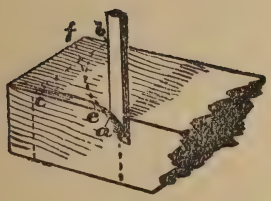
Showing *Skew chisel* (at the left), with basil on each side. Used for carving and a similar form for turning. A skew chisel sometimes has a basil on one side only. Also (at the right) *Back-bent chisel*. Useful for work in corners and angles. The *Corner chisel* is useful for paring inside corners. The *Butt chisel* has a short blade, convenient for setting hinges, paring mortises, etc.

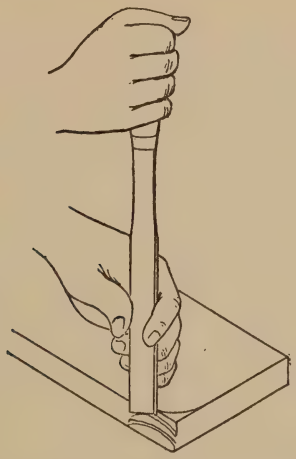
blade. For most work use the flat side of the blade against the wood. Cutting with the basil against the wood is sometimes necessary, however, and is often the best way to remove surplus wood. If the wood cannot be firmly held by the hand which also holds the blade, fasten it in the vise, or in some way, for it is essential that both hands hold the chisel, and also that the wood does not move. Watch the grain and cut so that the chips and splitting will be in the waste wood and not in the part you wish to keep. For paring and trimming, a large chisel is better than a small one. One with bevelled edges is often best. Light paring chisels for very fine work in soft wood can have a long basil at the cutting edge, sometimes $\frac{3}{8}''$ or $\frac{1}{2}''$ long. For heavy work and hard wood the basil must be much shorter. Sometimes you can only push the chisel straight ahead, but a shearing cut (**77**) is often best for paring. To strike the chisel, always use a mallet for heavy work. For light work, where only gentle blows are required, it is the common practice with skilled workmen to use the hammer (the side of the head), because the damage to the chisel handle on *light* work is trifling compared with the waste of time and the inconvenience of using a mallet. Test your chisel work by eye and with other testing instruments. Much work once done with the chisel is now done by machine. For sharpening, see **248,** etc.



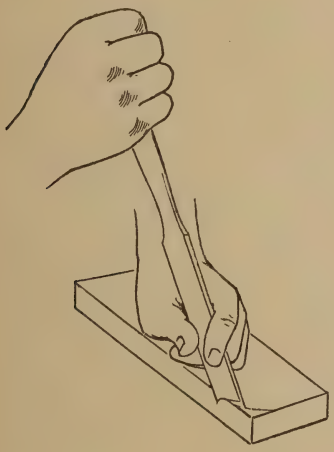
84. From which end should you pare with the chisel?

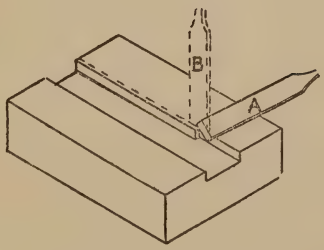
85. Trimming to a line. To trim to the curve *ab*, work with the grain from *a* to *b*. It often helps to saw off part of the waste wood first, as on the lines *bc* and *ef*. Push with the right hand and control the cutting with the left hand, which





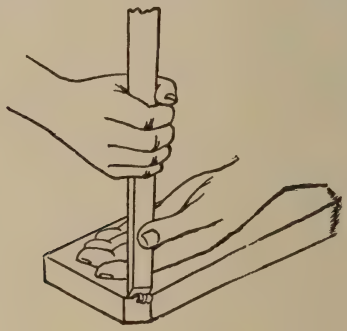
also holds the wood firmly. Cut with the grain (**292, 293**) so that the chips come in the waste.



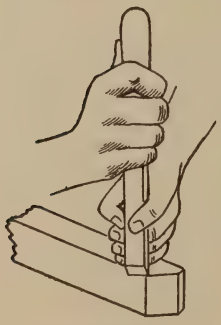


86. Shearing cut. Begin in position shown at the left. As you press down also push from you until the tool is upright (**85**), so that the edge will make a shearing cut (**77**). Cut with

the grain so that the chips come in the waste wood. This is the way to widen or trim a groove or dado (**463, 464**); for example, as shown at the right, edging along with slight cuts of $\frac{1}{8}''$ to $\frac{1}{4}''$ at a time, and keeping the flat part of the blade bearing upon the part already cut.[1] A shows position of chisel at beginning of cut and B position at end.



87. Another position for left hand.

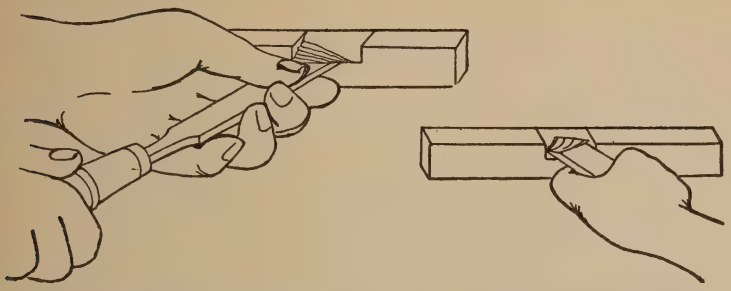


BEGINNING CUT

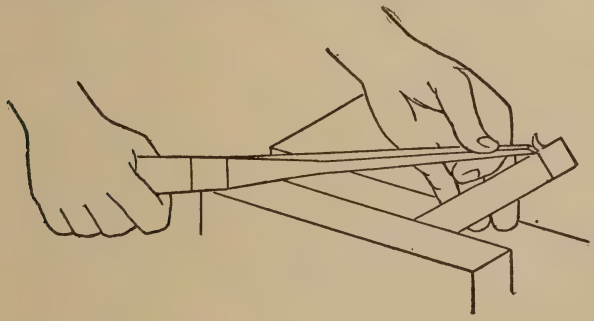
END OF CUT

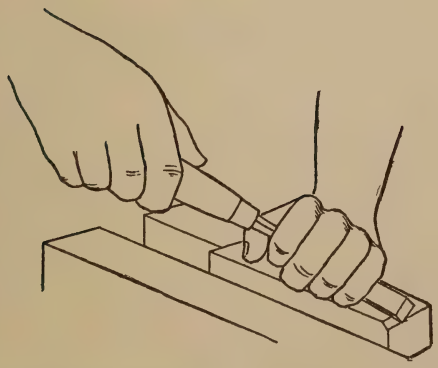
88. Shearing cut. Push down and edgeways at the same time. Cut with the grain.

[1] The edge of a square, or other straight-edge, can sometimes be used as a guide for long, straight cuts with the chisel.

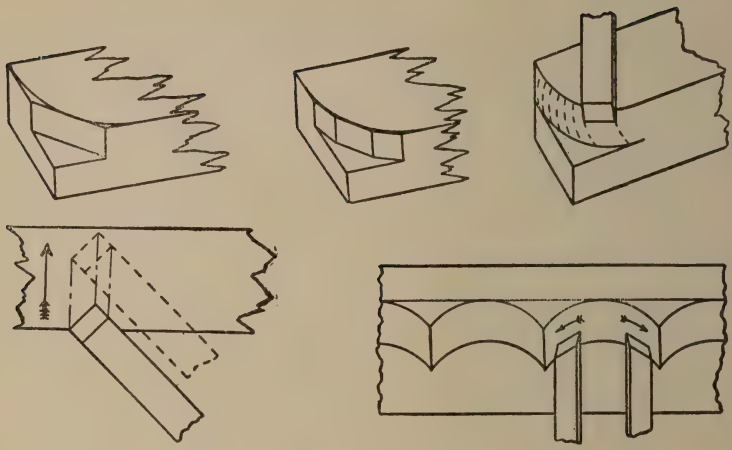


89. Shearing cut made by moving chisel handle sideways. The left hand bears against the wood and keeps the chisel from getting out of control and cutting too much.

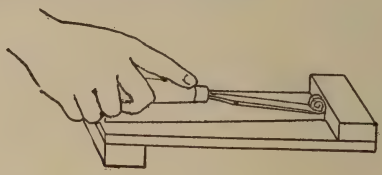




90. Paring across an end. Chisel handle swung around to one side causes a shearing cut.



91. Suggestions for use of chisel.



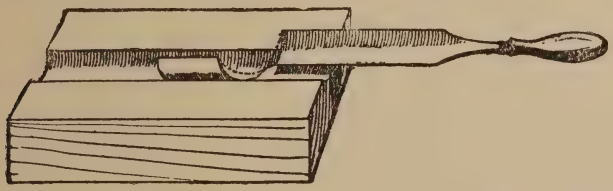
92. Paring with one hand.

Summary. To pare with chisel have wood held securely. Push tool with one hand, hold back with the other. Cut with the grain. Short basil and stout chisel for hard wood and rough work, long basil and lighter chisel for fine paring in soft wood, medium basil for general work. Use shearing cut when you can. For heavy work, see *Mortising*, **467**. For *Carving*, see **344**.

Gouge

93. Gouge. This is controlled like the chisel (**83**). The common or "outside" gouge has the basil on the convex side, and is useful for many odd kinds of work, like hollowing the

hull of a model boat, for pattern-making, etc. The "inside" gouge, with the basil on the concave side, is useful to trim holes or other openings, for carving, etc. Cut with as long strokes as possible.[1] For sharpening, see **248, 259,** etc.



94. Shearing cut. Roll the tool around as you push it forward (77),—particularly useful with crooked grain and in difficult places.

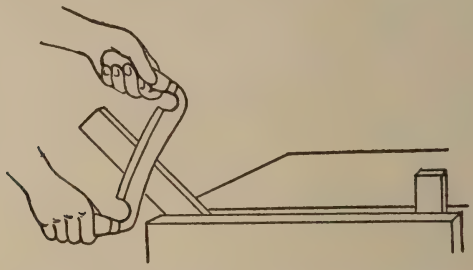
95. Cutting across the grain. Often the best way to remove surplus wood and to "rough out" odd-shaped work. Much done in carving.

Drawknife or Drawshave

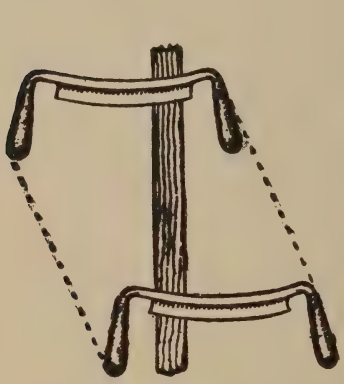
96. Drawknife or **Drawshave.** For roughing out work, cutting away waste wood, and trimming odd shapes. It is apt to cut too deeply and to split the wood. Cut with the grain. For sharpening, see **248, 263,** etc.

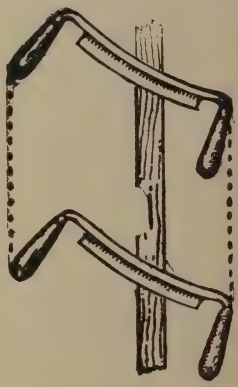
[1] **Sweep.** Gouges have many different sizes and degrees of curvature or "sweep."

97. Trimming to shape with Drawknife. Use flat side against the wood to make a straight cut, but often the grain of



the wood, or the shape to be cut, makes it better to have the basil against the wood.[1]





98. Shearing cut. Draw the tool sideways across the wood while pulling it toward you, or slant the tool and pull it straight toward you.

Saw

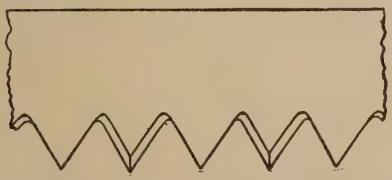
99. Saw. The *Cross-cut saw* is for sawing across the grain. The *Rip saw* is for sawing with the grain. There are many

[1] The waste piece in the right hand end of the vise is to equalize the pressure.

others for various uses, as the Back saw, Compass saw, Turning saw, Coping saw, etc.[1] For sharpening, see **270**, etc.

100. The set. The teeth are all bent outward (called the "set"), one tooth to one side, the next to the other side, so that

the cut (called the "kerf") is wider than the thickness of the saw blade. This lets the saw slip through the wood easily. The blade is also taper-ground,—thinner toward the back and end.



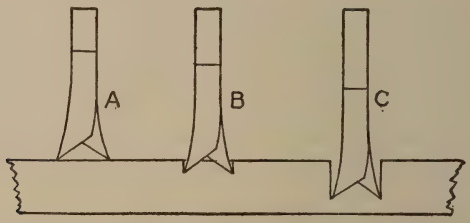
101. Cross-cut saw. The most important saw. The teeth have sharp edges and sharp points, like little knives.

102. Enlarged view, looking directly at back of saw, toward tooth edge, showing how the "set" extends the "points" of the teeth beyond the body of blade, so the latter will not bind or wedge in the cut.

103. If you hold a well-filed cross-cut saw with the teeth upward, a needle will slide the length of the blade.

[1] Keep saws clean with sperm oil. If rusty, clean with fine emery cloth, wipe dry, and oil with sperm oil.

104. Showing set and cutting action. The sharp points make parallel cuts across the wood, and the sharp edges trim away the wood between.[1]



A—scoring. B—entering deeper and deeper until **C—the** full bite is taken.

105. Place the work on horses, or in the bench vise, or on some firm support. Hold the forefinger of the right hand against the side of the handle, as shown below, to steady the saw.

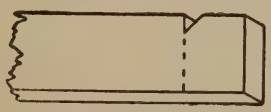
[1] The teeth are filed so that the front cutting edge is *drawn* across the wood much as you would draw a knife point across. Green or wet wood requires a coarser saw than dry, well-seasoned stock, and soft wood than hard. But little set is required for dry hard wood. Soft wood needs a wider set to give the blade clearance, because the fibres of the looser-textured soft wood are bent aside by the action of the saw teeth and are not so cleanly cut as in the hard wood.

Sizes. Eight to ten points, or seven to nine teeth, to an inch, are suitable sizes of teeth for common work. 26″ is a popular length. The smaller sizes (24″ or less in length) are called *panel saws.*

106. Use the thumb of the left hand to help start the saw on the line.[1] Have your eyes vertically over the line so that you can look on both sides of the saw. This will help to keep the saw blade at right angles with the surface of the wood.

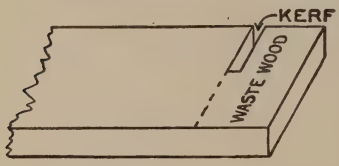
107. When the saw is in position, draw it gently toward you, and then push it gently from you. After one or two easy strokes, remove the left hand from near the teeth, and saw

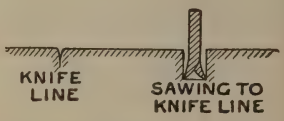
with light, steady, rather long strokes, guided by the lines you have marked on the upper side and on the edge of the wood. When near the end of the cutting hold the loosened end of the wood with the left hand to prevent splintering.



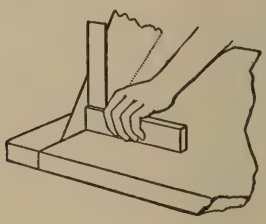
[1] A notch can be cut in which to start the saw, and can even be carried across the whole width of the surface, where extreme accuracy is required, but such methods are to be recommended in unusual cases only. Learn to do ordinary sawing without such help.

108. **The kerf** (saw cut) should come in the waste wood. The most workmanlike way, when the end will not need to be

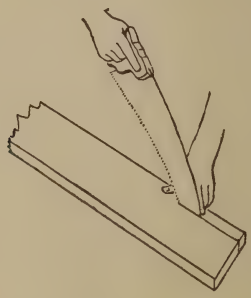




planed, is to saw just on the outside of the knife-line you have marked,—to "split the line," if you can. When the end must be planed, allow perhaps $\frac{1}{16}$" more for planing to the line.



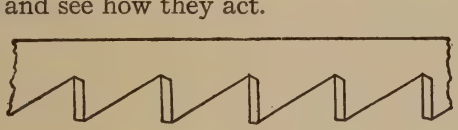
109. **Testing for a square cut.** Learn as quickly as possible to saw without having to test in this way. It is easier to follow the line on the surface than to cut at right angles to the surface.



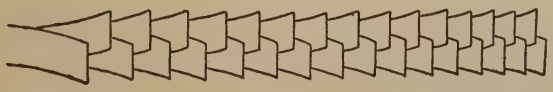
110. **If not sawing squarely,** bend the blade sideways as you saw. Use the tip of the saw when doing this.

111. Twisting saw to regain the line. If you run off the line, twist the saw to bring it back. Use tip of saw when doing this.

112. Rip saw. Sawing with the grain. The cross-cut saw will saw with the grain also, but the rip saw works more quickly. The cross-cut saw is sometimes better for ripping through bad knots and hard, crooked-grained spots, and for fine work in thin wood, plywood, etc. Try cutting *across* the grain with the *rip saw*, also *with* the grain with the *cross-cutting saw*, and see how they act.



113. The teeth. Properly filed rip saw teeth (shown enlarged) are like little chisels with square, sharp ends, for cutting lengthways of the grain only; that is *with* the grain.[1]



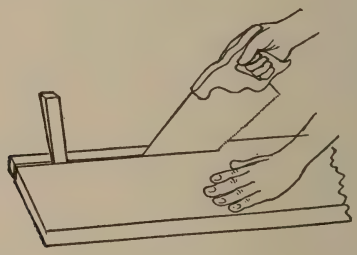
114. The set arranges the teeth in two overlapping parallel rows. Each tooth is pushed through the wood as you push

[1] Five to seven points, or from four to six teeth, to the inch are good sizes of teeth for common work. 26″ and 28″ are common lengths.

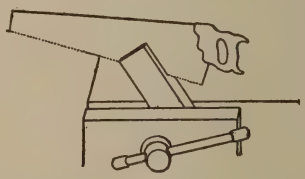
a chisel (92) and pares off a little from the ends of the fibres of the wood; thus the rip saw cuts on the forward stroke only.

115. **Enlarged view of cutting edge of rip saw.**

116. **To saw,** use the rip saw like the cross-cut saw, as already shown. If the edge is to be planed, saw a little (perhaps $\frac{1}{16}''$) outside the line.

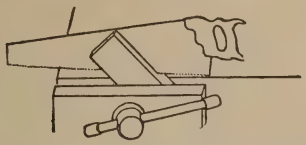


117. **Opening kerf with wedge** if it binds the saw. The cut shows also the **correct slant for sawing.** Therefore you can usually rip better with the wood placed on horses than when held upright in the vise.

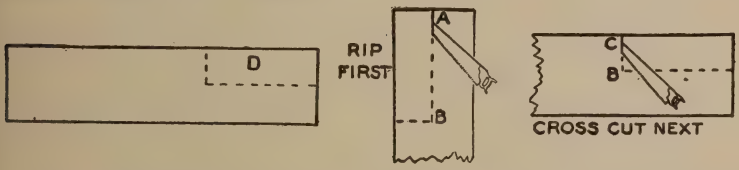


118. **Showing wood tipped from you** in the vise in order to use the saw with the proper slant.

119. **When sawing work like tenons (467, 475),** for example, after cutting part way as shown in the last illustration (118), reverse the piece and saw from the opposite corner as shown below, and so on. Thus you have to follow only the lines on the surfaces toward you, and the saw is partly guided

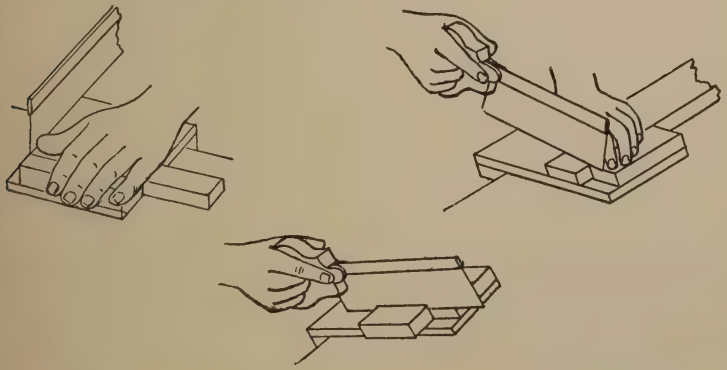


by the kerf already cut. As your skill increases you can saw farther without reversing.



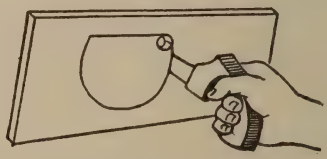
120. **To get out the piece D,** saw lengthways (A to B), and then crossways (C to B), because this is the way least likely to injure or waste the stock.

121. **Back saw.** For nice, small work. Has fine cross-cutting teeth. Secure the wood in the vise, on the bench-hook (8), or otherwise,—flat pieces with the flat side up, because you can follow the line better than with the edge up, for the back-saw must not be bent. A 10″ saw with 15 points to the inch is good for common work.

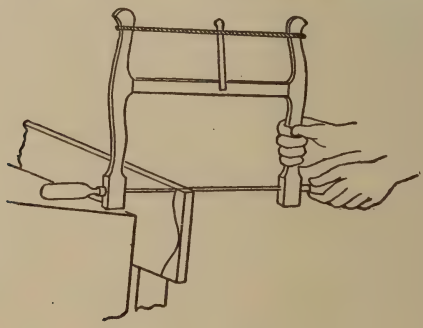


122. **Showing a common use of back saw.** Begin at the edge away from you with the handle raised as shown, adjust

the saw with the thumb of the left hand, and gradually lower the handle as you saw, until the teeth cut the whole width of the wood. Very small strips can sometimes be sawed best by holding the saw in the vise, teeth upward, and passing the wood back and forth over the teeth. See also *Mitre-box* (**128**), *Joints* (**447**).



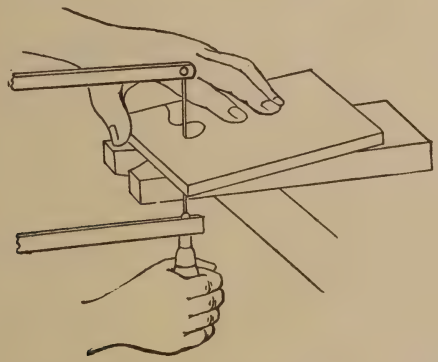
123. Compass (and **Keyhole**) **saw.** A narrow, tapering saw for cutting curves, and for starting a cut at a distance from an edge for the insertion of a hand saw. To saw a hole or inside openwork, bore a small hole in which to start the saw as shown. If the curve becomes sharp, use the tip of the saw. The teeth are a compromise between cross-cut and ripping teeth. For very small holes use the smaller *Keyhole saw.*[1]



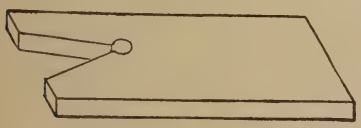
124. Turning saw (also called **Bow saw** and **Web saw**). For sawing curves. Hold the saw at one end, not by both ends. The teeth can point toward or away from you, according to

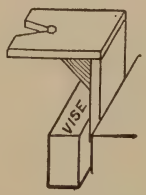
[1] When you have to make a very sharp turn, run the saw back and forth without trying to cut ahead, at the same time slowly turning the saw until it has worked its way around. Quick turning may bend or break the saw.

the kind of work and the way it is held. Use the left hand to start the cut in the right place, as with the hand saw (**106**). Turn handles and blade sideways in the frame when necessary. Use a light, easy, long stroke. Try to keep the saw blade at *right angles* with the surface of the wood. To saw a hole or inside openwork, bore a small hole, unfasten one end of blade, pass blade through hole, and re-fasten.[1]



125. Scroll saw, Jig saw or **Fret saw.** Used for fine work in thin wood. Teeth must point downward. To follow the pattern, turn the wood, not the saw. Run the saw straight up and down, as shown.[1] To saw a hole or inside openwork, bore a small hole in which to start the saw (**123**).



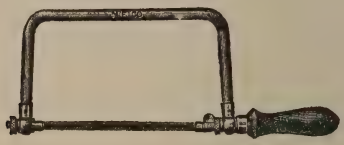


126. Support for wood when sawing vertically. Clamp to bench, and place the wood so that the saw can run up and

[1] When you have to make a very sharp turn, run the saw up and down without trying to cut ahead, at the same time slowly turning the wood until the saw has worked its way around. Quick turning may bend or break the saw.

down in the hole. By attaching a vertical piece this support can be held in the vise.

127. Coping saw, for cutting small curves in fitting mouldings, and for any small scroll work, etc. Used like the scroll



saw (**125**). If the work be held in the vise, the teeth can point from you. Whether the teeth should point from or toward you depends upon which is the face side of the wood and upon how the wood is supported or held.[1] See **517.**

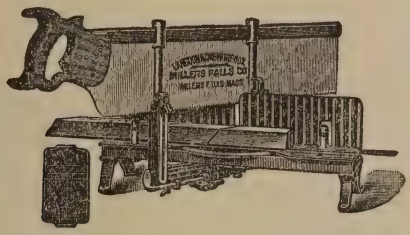
Summary. The set of the teeth should be enough for clearance merely. Cross-cut teeth act like little knives, rip saw teeth like little chisels. Take position with eyes in line with saw blade. Use thumb of left hand to start saw on line. Begin slowly. Saw with light, long strokes. Have kerf in the waste wood. Use rip saw at about 45° when you can. If you run off the line or are not sawing squarely, use tip of saw and twist or bend it slightly. Use back saw for fine work only. Place side of piece up, rather than the edge, when using back saw; and begin, usually, at the farther edge, lowering saw to the line as you cut. With narrow bladed saws for curves keep saw blade at right angles to surface of wood. If the work

[1] Small wheels for toys, checkers, and the like can be quickly made by taking, or making, a cylinder of wood and sawing off pieces of the desired thickness with the circular saw (**585**, etc.), or by hand with a mitre-box and stop (**131**). A wheel-cutter can also be used in the bit brace. This is merely a cutting knife revolving around a spur for a centre. A cutter for making leather washers can be used. Wheels and the like can be made by sawing the shape a trifle too large and finishing accurately with the disk sander (**666**). For producing in large numbers, the sawing can be done with the Band saw (**629**) or Jig saw (**642**), or they can be made entirely by turning with the lathe (**672**).

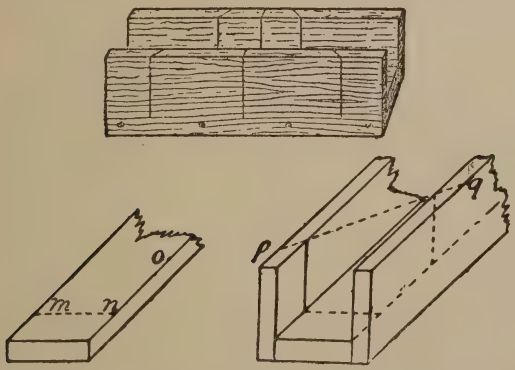
rests on a support, run the saw up and down, and turn the wood, not the saw. Adapt size of saw to the work. Cut sharp curves slowly. To saw holes, bore small hole for inserting saw.

Mitre-box

128. Mitre-box. For sawing at different angles. A metal box is best.[1] Much mitre-box work is now done by Trimmers

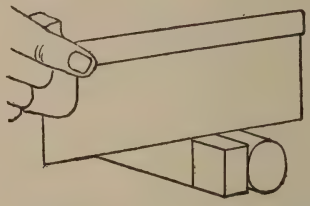


[1] To make an accurate mitre-box requires skill. Pine or beech is good. Do not use spruce or any wood liable to warp or twist. Square a line, *m n*, across the top side of the bottom piece, before putting together; and lay off from one end of this line a point *o* on the edge, at a distance equal to the

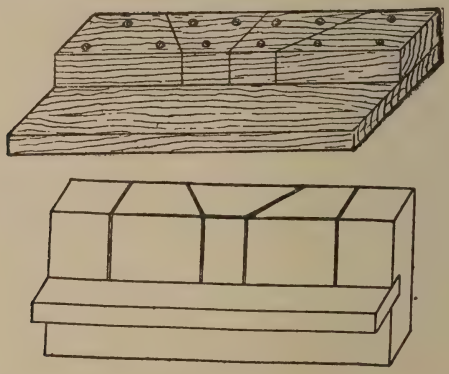


width of the bottom, thus fixing the points *m*, *n*, and *o*. Next fasten on the sides, square upright lines on the inside of one side from the point *m* and on the inside of the other from the point *o*. The diagonal line *p q* will represent the mitre. Saw the kerf with a back saw or a panel saw. Also

(159), Sanders (664), and the Circular saw (585). See also 508, etc.



129. **To saw a cylinder,** use a mitre-box, or a rectangular piece for a guide.



130. **Mitre guides for light work.** Be sure the surfaces and edges are square and true. Mark the lines first on the bottom of the upper piece, then on the edges, and lastly on the top as shown in footnote (128). See 146, footnote 2.

131. **When many pieces are to be cut of the same length,** fasten a block or stop to the inside of the mitre-box or to an extension of it. Place one end of each piece against this stop for each sawing, and the pieces will have the same length.

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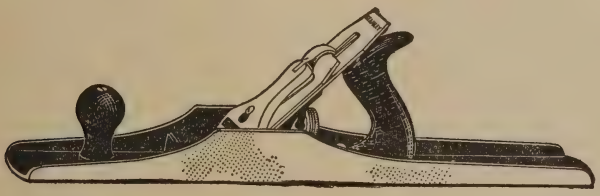
square on the inside two upright lines opposite each other, draw a line across the tops of the sides to meet these lines, and make a kerf, as shown by the middle line in the first illustration, for square sawing.

See *Circular saw* (606). For planing and trimming ends, see *Mitring* (510), *Trimmer* (159) and *Sander* (664).

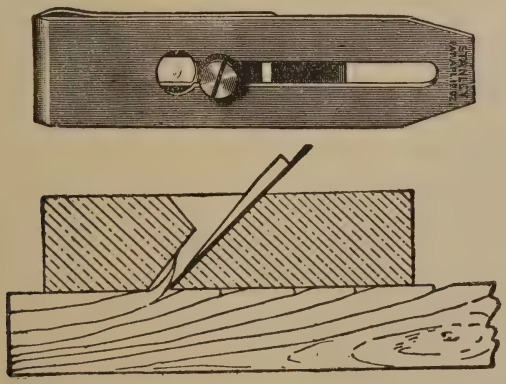
Plane

132. Plane. Probably the plane was originally merely a chisel stuck through or attached to a block for smoothing surfaces.



133. The Jack plane is for general work and for roughing off surfaces. It will do for ordinary work.[1] A shorter "junior" Jack plane is useful for small work.

[1] Learn the adjustments from the plane itself. The plane-iron or "bit" does the cutting. The bottom of the plane is called the "sole," the wedge-shaped space above the cutting edge is the "throat," and the slot in the sole is the "mouth."



The cap-iron, which has a dull edge, is screwed to the back of the plane-iron. If the cap-iron were not used when planing against the grain or for

134. Other planes. The *Smoothing plane* is best for smoothing a surface and for making small pieces flat. The *Block plane* (152) is small, light, and cheap. Useful for planing ends, and for work which has to be held in one hand while the plane is used with the other hand. It has no cap-iron (see footnote) because it is meant for planing end-grain. The cutting-iron is set at an acute angle and has the basil on the upper side. The *Jointer* is long, for straightening, flattening, and truing long edges and surfaces (144). The *Fore-plane*

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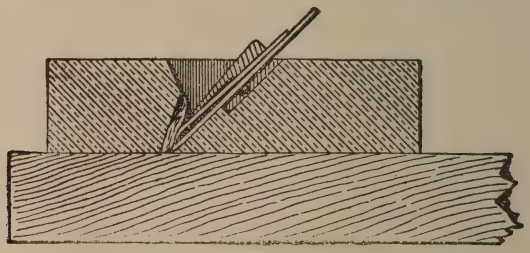
cross-grained wood, the surface would be apt to be rough, because the shavings would tend to split down into the wood ahead of the cutting edge.



The cap is added to bend the shavings up against the forward edge of the mouth, so that they can be cut off smoothly before splitting begins.

Screw cap-iron firmly to plane-iron so that the edge is from $^1/_{16}$″ (or occasionally a little more) to $^1/_{64}$″ back from the cutting edge of the plane-iron. It must fit tightly to the plane-iron, and be screwed to it firmly so that shavings cannot pass between them. For fine work and hard, crooked-grained wood the cutting edge should project beyond the cap-iron less than for coarse work and soft wood. With a wide opening at the mouth the shavings, when the grain is bad, will not be bent up by the cap-iron in time, because the angle against which to bend them is not near enough; therefore for fine work with hard, crooked-grained, or knotty wood have the opening at the mouth narrow, as just shown, the iron set fine, and the cap near the cutting edge. Upon removing the cutting iron from the plane you can see how the "frog," upon which the plane iron rests, can be moved forward or backward. For general work the cutting-edge should be

is a short Jointer. There are many planes for special uses.[1]

Some workmen still prefer the old-fashioned wooden planes. There is a desirable lightness and smoothness about their action. The wooden stocks, however, become warped or worn, sooner or later, and then the sole has to be "jointed" or made

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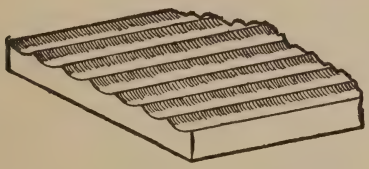
sharpened either squarely across or rounding *very* slightly. The Jack-plane was originally used for rough planing only and the edge was rounding, leav-



ing a series of hollows (as shown, exaggerated). It is still sometimes so used but rough stock is now planed almost always by machine.

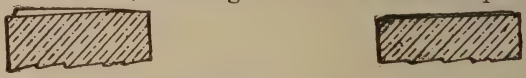
[1] The *Router*, for smoothing the bottoms of grooves or other depressions, the *Plow*, *Dado-plane*, *Rabbet-plane*, *Matching-planes*, *Circular plane*, *Bull-*

ROUTER

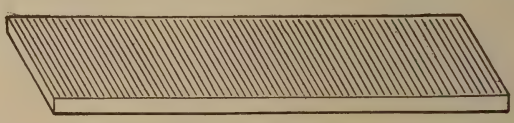
nosed plane, *Universal plane*, etc., are still used for special purposes; but machinery now does most of their work, except in emergencies. Their use is easily learned. The importance of these special planes depends upon what kind of work you are doing and whether you can have the advantage of machinery. The *Toothing plane* is used in veneering (580) and to prepare other surfaces for gluing. See 430. This plane is also sometimes used in smoothing very crooked-grained surfaces which are hard to smooth with a plane. Toothing breaks up the fibres so that the surface can be smoothed with the scraper. A finely sharpened plane iron is supposed however to smooth the most refractory grain, but this requires skill in sharpening and adjusting the tool.

flat. Iron planes are easier to adjust and to keep in order. The iron of a wooden plane, if it has no adjustments, is raised by tapping on top of the fore end (or on the rear end of the smoothing plane), and fixed by tapping on top of the "chip" or wedge which holds the iron in place. The iron is lowered by tapping on its upper end and then on the chip. If the cutting edge projects unevenly, tap on one edge of the upper part of the iron. For sharpening plane irons, see **248**, etc.

135. Adjusting the cutting edge. Face the light, turn the plane over, and look along the sole. The edge should project only about $^1/_{32}$" or less, usually. Adjust by turning the round nut in front of the handle to the right or left. For very rough work, or where much wood has to be removed, the edge can project a little more, drawing it back for the final planing.



136. If one corner projects more than the other so that the planing will be uneven, move the lever, just under the top of the plane-iron, to the right or left until the edge projects evenly.



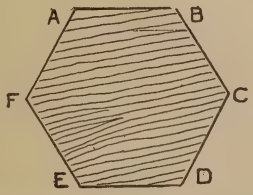
137. "Planer-marks" on machine-planed stock (see **651**). For nice work these must be smoothed off by hand or by scraping or sanding machines, lest they show when the work

is finished. For some things machine-planed stock is smooth enough.

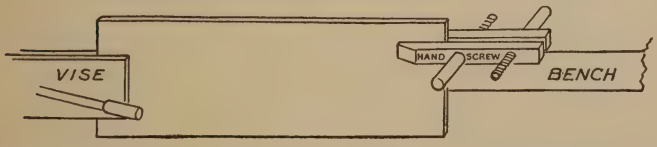
PLANING WITH THE GRAIN

PLANING AGAINST THE GRAIN

138. To plane the edge of a board. First fasten the wood in the bench-vise, or otherwise, so as to plane with the grain, if possible.

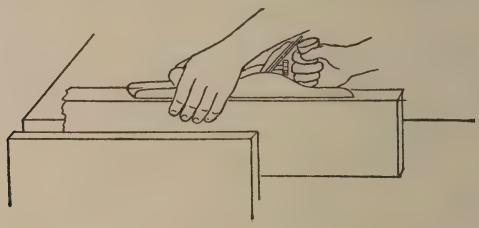


139. In which direction should you plane each edge?



140. Place the wood low in the vise, for it is hard to plane much higher than the top of the bench. A hand screw can be used to support the end of a long piece or of a wide board so that the edge can be kept low.

141. Operation of planing. The edge must be planed: (1) straight, and (2) square with the side of the piece. Look along the edge (56) to see where the most planing is needed.

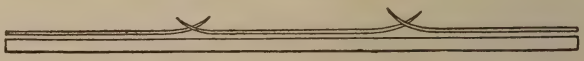


Hold plane as shown, with fingers of left hand against the side of the wood to help guide the plane and keep it steady.

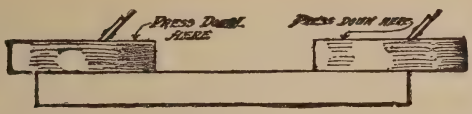
To make the edge straight the plane must be kept *flat on the wood* for the whole stroke. Stand at the *rear* end (the end to the right as you face the bench), with one foot in advance, and begin to plane at the *rear* end. Plane slowly. Watch the mouth of the plane to tell by the shavings how well you are planing. Keep the plane lengthways of the wood.[1] Take long, steady strokes, the final ones the length of the wood if possible.[2]

142. To keep the plane flat on the wood, press down on the forward part of the plane with the left hand during the first part of the stroke, and on the rear part with the right hand

[1] It can be turned slightly, sometimes, provided the whole length of the sole be kept on the wood. A very small piece can sometimes be planed best by turning the plane upside down and passing the piece over the cutting edge, using care to avoid planing the fingers.



[2] Feathering the strokes (greatly exaggerated). If you have to start or end a stroke at any other point than the end of the piece, the rear end of the plane can be lifted slightly from the wood at the beginning and end of the stroke, thus tapering the ends of the shaving. A light, easy movement in placing and raising the plane is all that is necessary. This is not easy to describe but can be learned by experiment.

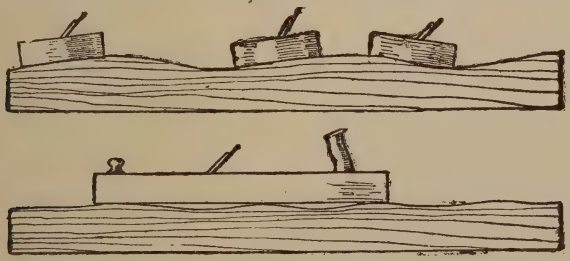


during the last part of the stroke, removing the left hand at the end.

143. **Result of not keeping plane flat** on the wood at each end of the edge. The plane is also apt to jump and chatter, leaving hollows and ridges across the surface. Beginners often

plane with a rocking motion which produces the rounded edge shown above. Therefore, if you have this tendency, plane as if you were trying to make the edge hollowing instead of straight.

144. **A long plane (Jointer) makes a straighter edge** or surface than a short one (Smoothing-plane), because the former planes away the high spots until the surface is straight, while the latter can follow the irregularities of the surface. After planing a little, test for straightness (**56, 57**) and for square-

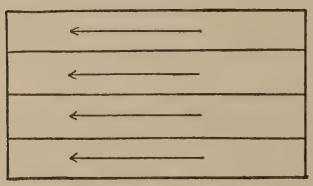


ness (**58**). If not straight, plane the high places, test again, and so on until straight. To test the squareness of the edge, square from the edge to the side or face, because any error can

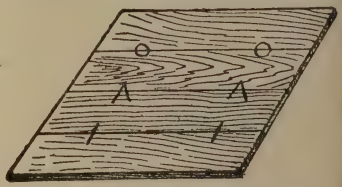
be detected better by the long blade on the flat surface than if the blade be held across the edge.

145. Planing high side of edge. If not square, move the plane over sideways so as to plane the high side only. Try to keep the plane flat, and steady it with the fingers of the left hand (**141**) against the wood. If the edge of the plane-bit is very slightly rounded, it will take off a shaving a little thicker on one edge than on the other. Thus by moving the plane to the high side the edge of the wood can be made square. Attachable guides for planing squarely or at any other angle can be bought.

146. Planing (jointing) edges for glue joints is now done with the Jointer (**655**) or the Circular Saw (**604**). Before planing, arrange the pieces so that the grain will run the same



GRAIN RUNNING THE SAME WAY



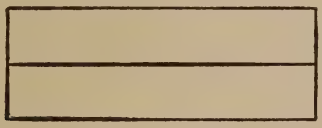
PIECES MARKED TO PREVENT MISTAKES

way in each, if you can, because the surface will plane and finish better, after gluing, than if the grain runs in opposite directions[1]; and mark the edges which are to join, to prevent

[1] Sometimes, however, with handsomely figured wood, the pieces are arranged with regard to appearance only, even though extra work may be required when smoothing.

mistakes when gluing. The best way is to glue the boards in the rough, before the surfaces have been planed at all, and after the glue is hard plane by machine or hand to the required thickness.

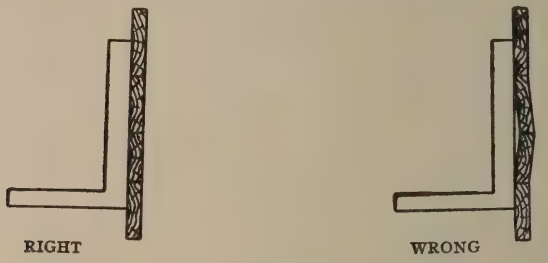
To plane the edges by hand, do them separately, from opposite sides,—that is, if the edge of the first piece is placed in the vise with the marked side of the board *toward* you, plane the next piece with the marked side against the bench, or *away* from you. This is to offset any unevenness in setting the plane-iron, tipping of the plane to one side, or warped condition of the pieces. Do not use the try square to test the edge when making glue-joints, but put one piece in the vise with the jointed edge up, place the next piece on it, and see if the edges touch throughout.[1] Strike the under board slightly to see if the upper one shakes or tips sideways or endways. Also slide the top board lengthways, for a sensation of adhesion or suction can be felt when the edges fit. Press down at the ends to see if they touch. If the edges do not touch throughout, one or both must be planed with thin, careful strokes until they fit, for the joint will not be good otherwise.[2] For gluing, see **426**, etc.



[1] It is common to make the edges slightly concave lengthways, so that they touch at the ends only, to be forced together for their whole length with clamps (**229**, etc.) at the center, after applying glue. This is probably the best way in many cases, but it is a question whether, with thoroughly seasoned stock, particularly with short pieces, there can be anything better than two straight edges fitting at every point and clamped for the whole length.

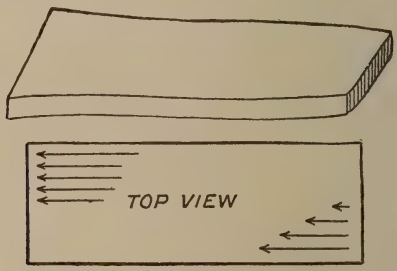
[2] *Shooting-boards* or *Jack-boards* can be used for jointing and planing edges straight, and at different angles, particularly for short, thin stock. The board is laid against a stop and the plane used on its side. Formerly shooting-boards for planing edges, mitres, etc., were in common use and can still be obtained if machinery be unavailable; but machines are now used.

147. Testing surface for flatness, with any straight-edge. Not only must the edges fit, as already shown, but the sides



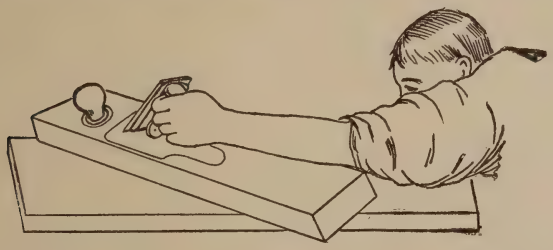
of the boards must form a flat surface, must be in the same plane.

148. To plane a broad surface, as the side of a board, hold the wood firmly on the bench with bench-stops (3), or in the vise, or in some secure way, and so that you can plane with the grain, if possible. Plane in the way already described for planing an edge, except that you grasp the knob of the plane with the left hand instead of holding the fingers at the side. Of course you have to keep moving the plane over from side to side in order to plane the whole surface. Look across the surface, or test with straight-edge, to see where the most planing is needed. The edge of the straight-edge can be chalked to show the high spots.

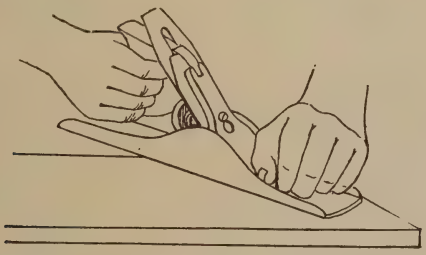


149. Planing a winding or warped surface. Plane the highest places first.

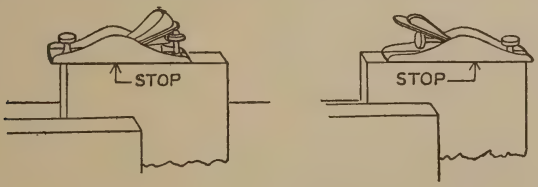
150. Testing surface with plane. Apply the edge of the plane, or any other straight-edge, crossways, diagonally, and



lengthways, and you can tell whether the surface is flat. If not flat, plane the high places, test again, and so on until it is flat throughout.

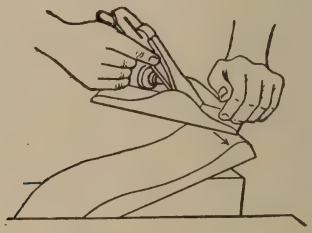


151. Traversing. Planing across the grain, or diagonally, when the wood is very rough or when much wood has to be planed off. The finishing strokes should be *with* the grain.

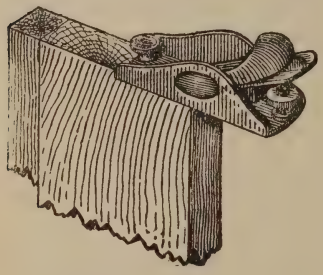


152. Planing end-grain. Fasten the wood low in the vise. Plane partly across from one edge, then reverse the piece and plane partly across from the other edge. This is to prevent chipping at the edge. Press down on the front of the plane to

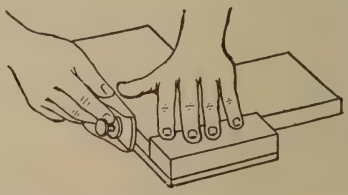
keep it flat on the wood. The Block-plane (134) is best, but the Smoothing-plane (134), or the Jack-plane (133) can be used. After planing, test with square (58), but if planing to a line, stop when you reach it. For fine work a knife line squared around the piece helps.[1]



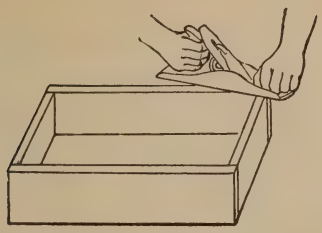
153. **Shearing cut** when rounding or bevelling an end (77).



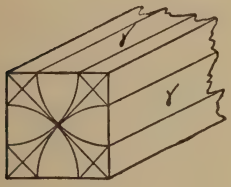
[1] Sometimes a piece of waste wood is temporarily placed at the farther end to prevent chipping, or the farther edge of a narrow piece can be trimmed off before planing.

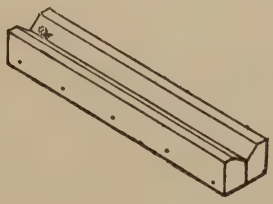


Planing end on bench-hook or jack-board, but planing by this method should be carefully tested with the square.

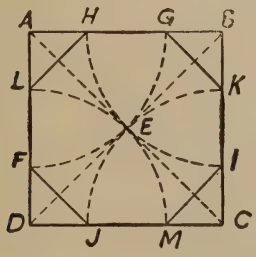


154. To plane the edge of a box, and in similar cases, keep the sole of the plane on both side and end at each corner, to prevent bruising with the end of the plane.





155. To make an octagonal stick by planing. First make it square in section. Mark an octagon on the end.[1] Gauge lines, with pencil, on the four sides of the stick from the angles



[1] *To construct an octagon within a given square.*—Let ABCD be the given square. Draw the diagonals AC and DB intersecting at E. From A, B, C, D, as centres, with radius AE, or BE, etc., describe arcs cutting the sides of the square in F, G, H, I, J, K, L, M. Draw LH, GK, IM, and FJ; and LHGKIMJF will be the octagon required.

of the octagon. Plane the four angles to these lines. A jig[1] or cradle to hold the piece is useful for the planing. When the stick is square in section, by measuring one-half the diagonal of the end, the lines on the sides can be drawn without completing the octagon on the end.

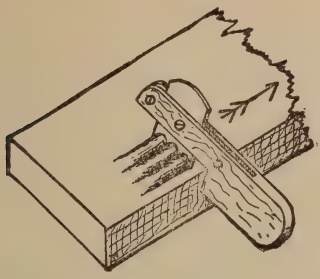
For Squaring stock to dimensions, see **296.**

Summary. Learn adjustments from the plane itself. Cap-iron bends shaving for smooth cutting. Adjust plane to make fine shavings, except for rough work. "Planer marks" must be removed for nice work. Have wood securely held. Plane with the grain if possible. Begin at rear end of the wood. Keep plane *flat on the wood.* Plane slowly, with long, steady strokes. Watch the shavings. Keep plane lengthways of the work. Use a long plane to secure straightness. Short plane for smoothness merely. Test by eye, square, edge of plane, etc. Plane high spots first. To reduce wide surfaces, plane crossways or diagonally first, then lengthways. Plane ends from both edges. Shearing cut good for bevelling or rounding ends.

Bead Cutter

156. Bead cutter. A tool for scraping beading, reeds, and the like, can be bought; or made by filing the reverse of the shape required on the edge of a piece of saw-blade steel and inserting this blade in a kerf in one end of a piece of wood like that shown. The tool is pushed forward like a scraper. Such

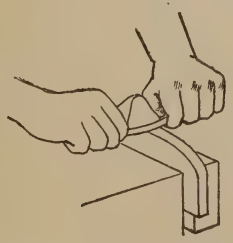
[1] Jigs or fixtures to hold or guide either the work or the tool, or both, are in regular use for quantity production, enabling an operation to be repeated many times with accuracy and speed. Usually it is not worth while to contrive a jig for doing a piece of work once. If a difficult operation is to be repeated frequently, it is best to make a jig, if practicable. The use of a jig is usually a purely mechanical or routine performance,—productive from the point of view of efficiency, but not educative. Contriving jigs, however, calls for much inventive effort and ingenuity, besides mechanical skill, and is distinctively educative.



work is now usually done by machine, but the principle of the bead cutter is often applicable to problems in hand work.

Spokeshave

157. Spokeshave. For shaping and smoothing curved or irregular surfaces but not for straight flat work, for which the sole is too short (see plane, **144**). Originally for shaping wheel-spokes. Frequently used to follow the drawknife. Much of the work of the spokeshave is now done by machinery, but it is still an invaluable tool for some kinds of work. The cutter should project very little, as with the plane (**135**). For sharpening, see **248,** etc.



158. Using spokeshave. Grasp firmly and push forward steadily so that it will cut like a plane. It can usually be controlled best when pushed from you, but it can be pulled toward you if necessary. A shearing cut is often best (**77**).

Trimmer

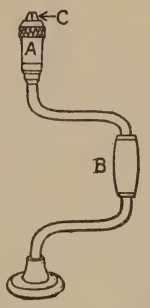
159. Trimmer. Cuts accurately at a variety of angles. The adjustments are simple. Trims with thin slicing cuts, using a shearing stroke (77). Do not cut over $\frac{1}{8}''$ for soft

wood or $\frac{1}{16}''$ for hard. The knives must be kept sharp. Have an extra set, so that sharp ones can always be in use. Fasten small machines securely. If much wood is to be removed, use a saw or other tool first, finishing with the trimmer. Large machines stand on a base. Much of the work of trimmers can be done with Sanders (664). See *Mitre-box* (128), *Mitring* (508, etc.), *Paring* (293), *Bevelling* (318).

Boring tools

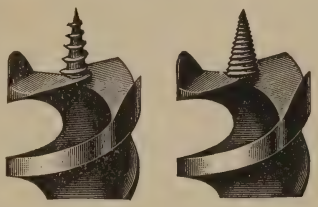
160. Boring tools. Common boring tools are the Brace and bits or drills, Automatic or Push drills, Breast, and Hand drills, Gimlets, Augers, Brad-awls, etc. See also Boring machines (669).

Bit brace and bits or drills.



161. Inserting bit in Brace. Hold the chuck (A) in one hand, and revolve the handle (B) of the brace with the other hand until the jaws (C) have opened enough to put in the bit. Insert bit and revolve brace the other way until bit is held firmly. To take it out, reverse the process.

162. Principle of the auger-bit. The point is a screw *a* (called the worm) which screws itself into the wood, as you turn the brace, and draws the whole bit toward the wood. When the scoring nibs *b* touch the wood they make a circular cut. Then the cutting-lips *c* pare off shavings. So pressure on the bit-stock is not needed usually,—unless the bit is dull. For sharpening, see **264.**



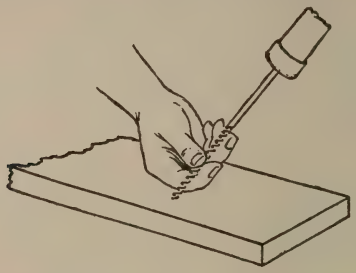
163. Single thread screw point for quick boring. For common work in soft wood, in end-grain, or gummy wood.[1] Also **standard double thread screw point,** for fine work. Bores more easily and leaves a smoother hole than the single thread.

164. Sizes. The number on the shank of an auger-bit is the numerator of a fraction of which the denominator is 16, and indicates the size. If the number be 8, the bit is $\frac{8}{16}$″ in diameter, that is, ½″.

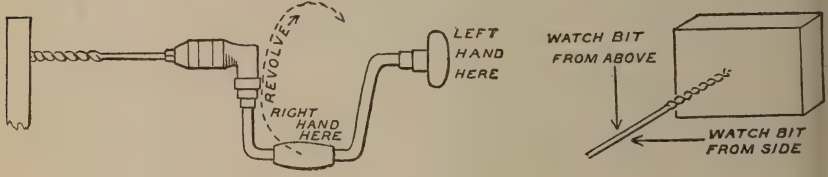
165. Starting bit at exact point. For accurate work with the auger bit, particularly in hard wood, before beginning to

[1] There are other fast-cutting bits for common work,—the Irwin with a "solid centre," the Ford with but one nib and one lip. For small sizes the gimlet bit bores easily, but tends to split the wood if thin or near an edge.

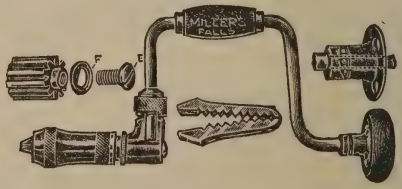
bore, punch a little hole to start the point or worm of the bit at the exact point, as it sometimes works off to one side.



166. Placing point or " worm " of bit at exact spot. Then raise brace to proper position for boring.

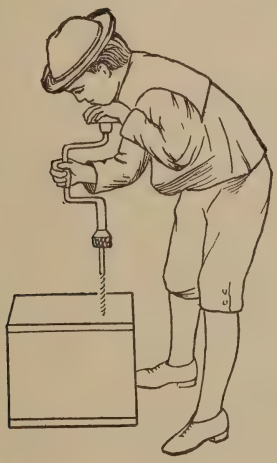


167. To bore squarely (at right angles to the surface), it is well to have the surface of the wood either horizontal or vertical. Lines squared across the surfaces help. After beginning to bore, sight from above or from in front and then from one side to see whether you are boring squarely. Keep sighting until the bit is well started. For important work have someone watch from one side while you watch from above or in front.

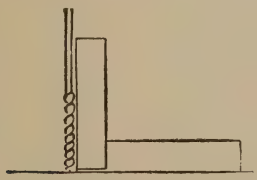


168. The ratchet brace can bore with only partial revolutions of the handle, and can thus be used where a complete

turn of the handle cannot be made. Sometimes in boring a horizontal hole, it helps to use the ratchet brace, boring with downward strokes only, instead of turning the brace all the way around.



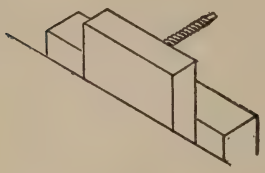
169. **Boring vertically** while looking down onto the work and moving around into different positions.

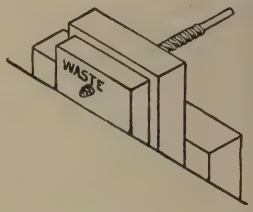


170. **Testing accuracy of boring with square.** Learn as quickly as possible to bore squarely by eye. See also *Dowelling jig* (504).

171. **To withdraw the bit** from a hole, give the brace a turn backward to loosen the worm or point. Then pull the bit straight out, at the same time turning the brace as if boring. This brings out the chips, but use care not to tear the wood at the mouth of the hole.

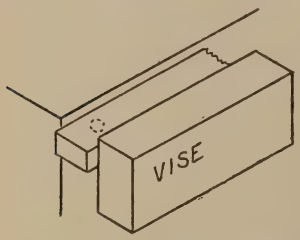
172. To bore through the wood. When the worm or point begins to prick through, stop boring, turn the wood, and

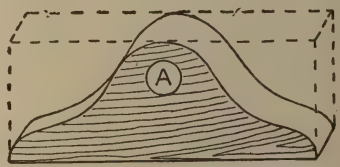




bore back. This is to prevent splintering when the bit comes through but use care or you may tear the wood where the bit first entered. For rough work you can bore through into a piece of waste instead of reversing the wood.

173. With a deep hole in hard wood, particularly in end grain, pull the bit out once in a while to clear out the hole. When the position of a long hole must be exact on both sides of the wood, mark the point for the centre of the hole on both sides, and then bore from each side until the holes meet.[1] For example, boring a tube. In such a case, draw a line lengthways on the surface if possible.

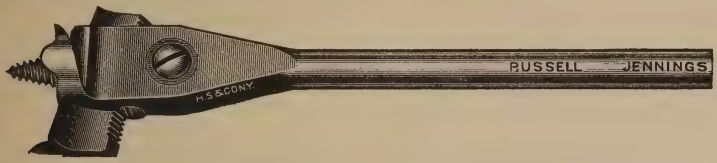




174. To avoid splitting. Fasten a small piece tightly in the vise, or a handscrew, while boring. Bore hole (A) before

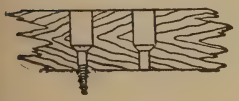
[1] In order to have the hole straight and at the same time at right angles to each side of the piece, the sides must be parallel. If the hole be long, the two borings may not meet exactly, but can be straightened with a hot iron rod, or some other tool. For large work of this kind use an auger with a handle.

sawing the curved side, otherwise the short grain near the hole may split when you bore.



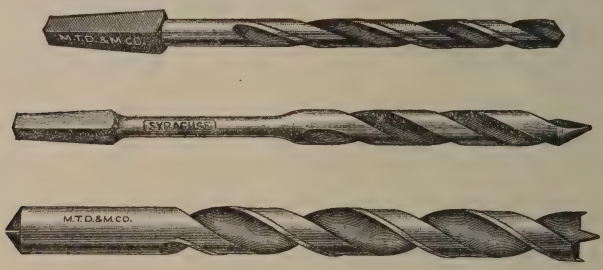
175. Expansive bit for large holes. For large holes in hard wood, bore a "pilot" hole first with ⅛" bit. When boring with an expansive bit would be too hard, use an auger with handle.

176. For a larger hole than can be bored, use a saw (**123,** etc.). If you have no saw for curved work, bore small holes just inside the line and trim to the line with gouge, spokeshave, or whatever tool may be adapted to the size of the opening,—a method for emergencies only.



177. Counterboring. Boring two holes in this way is often done to set the head of a screw or bolt below the surface. Bore the larger hole first. See **569, 555, 186.** If you have begun a hole with an auger bit, you can continue it with a smaller one but not with a larger one, because in the latter case there would be no wood for the worm or point to screw into (**162**). In such a case plug the hole with wood or use a metal plug with soft centre.

178. The twist drill is excellent, does not split the wood readily, and will bore in metal also. It breaks easily if bent. Ranges in size from $\frac{1}{16}''$ to $\frac{1}{2}''$. The twist bit for wood cuts

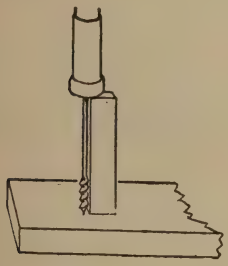


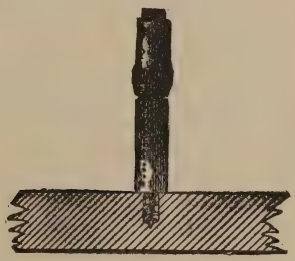
well and is not easily broken, but is hard to start exactly at the desired point, is liable to work off to one side, and bends easily. Ranges in size from $\frac{2}{32}''$ to $\frac{29}{32}''$. For sharpening twist drills and bits, see **264.** The Gimlet bit bores easily but tends to split thin wood or near an edge. The hand gimlet is also still used, although nearly superseded.

179. The Forstner bit can be used to bore in end-grain, for shallow holes in thin wood, in knotty places, to follow a smaller bit, to make rectangular or elliptical holes, etc. Bores slowly, as it has no worm. Makes a hole with smooth bottom.[1]

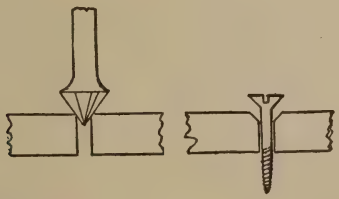
[1] The *centre-bit* is a useful tool, particularly for very thin stock. The spear-like point *a* acting as a centre, the point *b* cuts a deep ring, and the edge *c*, which is bent so as to form a flat chisel, scoops out the pieces of wood,

180. Bit-gauges, of various kinds, stop boring at a given depth.





181. If you have no bit-gauge, measure with a rule held beside the bit, or cut a stick. To make a tube is more accurate if many holes are to be bored. For rough work you can tell approximately by turning the brace the same number of times for each hole.



182. Countersinking hole for head of screw with a rose countersink used in bit-brace.

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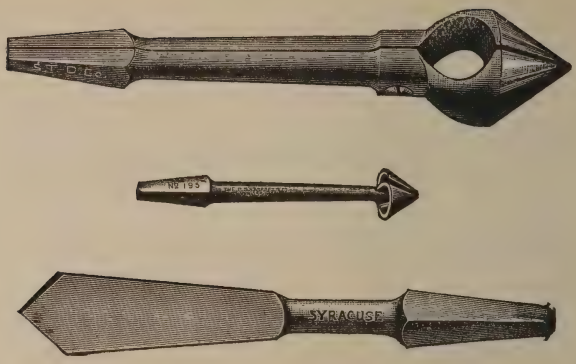
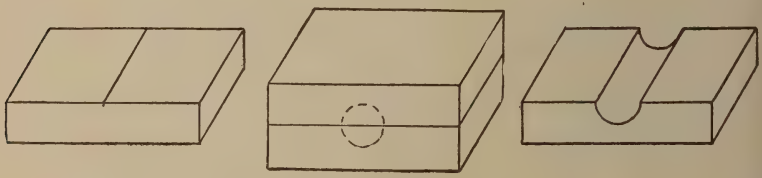
and so a round and smooth hole is made. This bit does not cut very well with the grain of the wood. It can be sharpened with a small oil-stone. It is well to bore a trial hole in a piece of waste wood when accuracy is required because the spur is not exactly in the centre, so that the diameter of the hole cut is a trifle greater than that of the bit.



FLAT METAL COUNTERSINK

183. Other forms of countersinks. *Reamers* for enlarging holes are useful. A countersinking gauge will stop the countersinking at the desired depth, as is desirable if there are many holes, for screws look best when sunk uniformly.

184. A template can be made if holes are to be bored in many pieces in the same relative positions, so that the points for all the holes can be found without measuring for each separately. The bevel can be used when boring at any angle, like the square as shown in **109**. There are various angle-boring and extension appliances for boring in places difficult to reach.



185. Boring where two pieces join, so that one-half of the hole will be in each piece. Mark line for centre of hole across each piece, make a very shallow saw-kerf in each, clamp pieces together, and bore from each side.

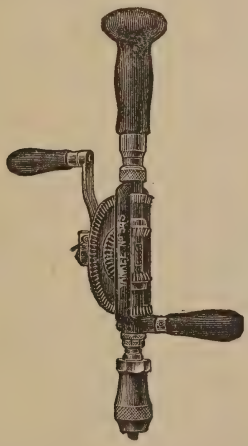
SCREW AND PLUG BIT

PLUG CUTTER

186. Covering the head of a screw with a plug of wood is easily done with these tools.[1] See also **177.**

Breast and Hand Drills, etc.

187. Breast and hand drills. Very efficient. Can be used often where a ratchet-brace would otherwise be needed. Such a tool can be changed from a plain drill to a left hand



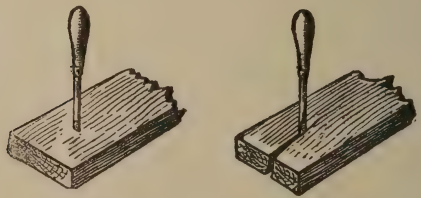
ratchet; to a right-hand ratchet; to a double right-hand ratchet, when any movement of crank, forward or backward, causes the drill to cut continuously. Small hand drills are useful for small holes. Screw-drivers can also be used.

[1] Hollow augers, and spoke pointers are occasionally useful.

188. **Push brace.** Takes auger bits up to ½″ and other bits and drills; also screw-driver bits (**222**).

189. **Reciprocating drill.** Grasp the "driver" in the right hand and move it backward and forward. The drill turns continuously to the right. Holds any drill with straight shank $\frac{3}{16}$″ diameter or less. Can be used for drilling metal also.

190. **Automatic push drill.** Very convenient for small holes.



RIGHT POSITION WRONG POSITION

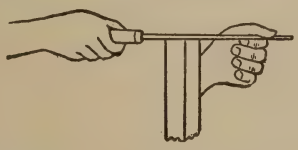
191. **Brad awl and gimlet.** Superseded to a great extent by the boring contrivances already shown, but still frequently useful. The awl should be not quite so large as the nail to be driven. Bore with the cutting edge across the grain, lest the wood be split by the wedge-shaped edge. The gimlet is apt to split the wood near an edge.

Summary. To bore squarely sight from different directions. The worm or screw of the auger bit draws bit into the wood while the nibs and lips score and pare the wood. To bore

through, stop when bit pricks through, and bore back from the other side carefully. Twist drills and bits, breast and hand drills, and automatic borers very desirable.

File

192. File. Fasten the wood firmly. Hold file handle with right hand, thumb uppermost, and steady the end with left



hand, thumb uppermost, or with the fingers or palm. Push straight forward with a long, steady stroke. Lift from the wood, bring back, push forward again, and so on. Press on the forward stroke only. To cut with a backward stroke dulls the file. The file should be used only where you cannot use the clean-cutting edged tools, not instead of them. Do not file metal with a file for wood. Press lightly when using a new file. To clean a file, soak in hot water and brush with file-

cleaner or stiff brush. The half-round, "slab-sided" or cabinet file is the most useful, and sometimes the round (tapering) or "rat-tailed" shape.[1] A half round combination of file and rasp (**193**) is useful.

Rasp

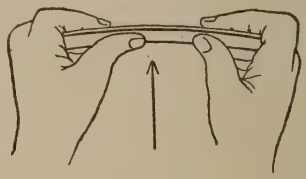
193. Rasp. The half-round rasp for wood is studded with points, which tear off the wood more quickly, but more roughly,

[1] When the teeth are cut in one direction only, a file is called *single-cut*, but when there are two oblique rows crossing each other, it is *double-cut*. These ridges incline toward the end or point of the tool, so that the file, like the rip saw, plane, and scraper, cuts when pushed forward.

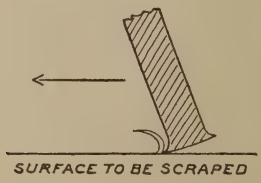
than the file (**192**). Useful to work irregular objects roughly into shape, but not a tool to begin with, for the learner is apt to prefer it to the edged-tools which he should be learning to use. Follow with a file or other finer tool to get a smooth surface.

Scraper

194. Scraper. The cabinet scraper is a thin piece of *very* hard steel and is used after the plane, for fine work, to make the surface smoother. Scrapers are made with handles, and are also set in stocks like planes. These are good for some work, but the hand scraper is best for the beginner. Scrapers with curved edges, and also pieces of glass, are good for rounded surfaces. Smoothing on a large scale is done by Scraping machines (**721**) or Sanders (**664**)



195. Using cabinet-scraper. Spring it slightly with the hands, so that the middle part of the edge, but not the corners, will touch the wood. Hold as nearly upright as will cut well, and push steadily from you. Raise from the wood, bring back, push again, and so on.

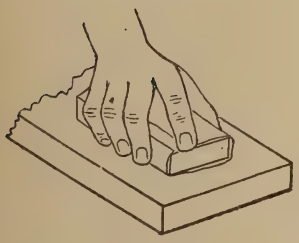


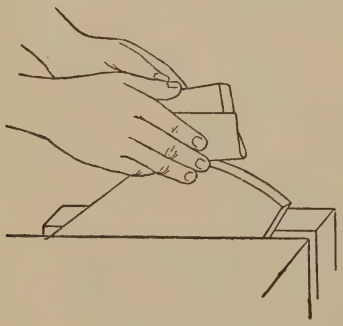
196. The turned-over edge shown (exaggerated) cuts, rather than scrapes, fine shavings. Examine the edge with a

powerful magnifying glass. It cuts only on the forward stroke. Each edge can be used. Scrape in any direction that will give the best result, but make the final strokes with the grain, as a rule. Test for smoothness by passing the fingers over the surface. When the scraper ceases to make shavings and only scrapes dust, it is dull. To sharpen, see **265, 266, 267.**

Sandpaper

197. Sandpaper and other abrasives. Do all cutting before sanding, for the grit dulls the tools. Sand with the grain, as a rule.[1] Use fine sandpaper for nice work. Do not sand joints by hand. Some joints can be sanded with sanding machines. Most sanding is now done by machine (**664,** etc.). The fineness of sandpaper is indicated by numbers. OO is as fine and 1½ as coarse as is needed for ordinary work. A sheet can be torn into smaller pieces by a straight edge or over the edge of the bench. Garnet paper is excellent. Steel wool is good for rubbing off and cleaning old finish.

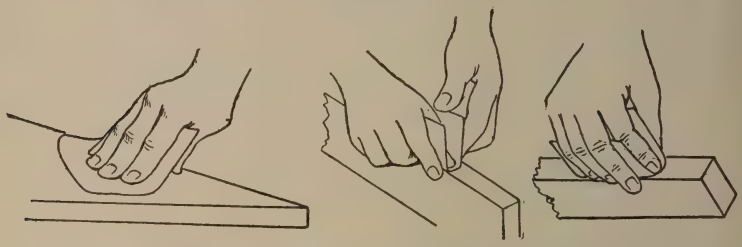




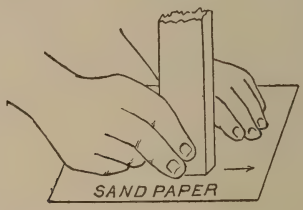
198. Sanding flat surface and edge with block of wood to make surface even and to prevent rounding edges. Cork

[1] Sanding across the grain, except with rounded surfaces, makes satisfactory finishing hard, because such parts absorb an excess of stain

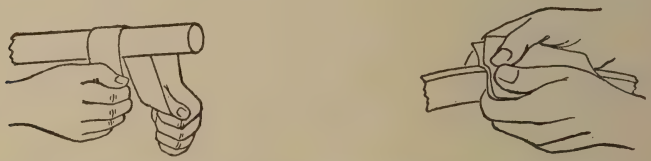
makes a good block for fine work. A block of wood can be faced with cork, rubber, or leather.



199. **Using paper without block** for flat surface and edge.



200. **Sanding small end** or a little piece. Rub it steadily over a piece of sandpaper laid flat on the bench. Reverse the piece, rub again, and so on.



201. **Sanding round or curved surface.** Draw paper back and forth *across* the grain, *around* the piece. Also showing (at the right) finishing curved edge *with* the grain. Thick rubber, or leather, makes a good block for curved surfaces.[1]

[1] Small articles such as checkers, if there are many of them, are often smoothed and polished by revolving ("tumbling") for a few hours in a drum together with scraps of wax. The drum is merely a cylindrical or polygonal box kept revolving.

For fine work to be nicely finished the angles of the edges (arrises) should be *very* slightly rounded—a mere touch, less than $\frac{1}{32}''$—to prevent rubbing through the sharp angles when finishing (**397**, etc.). There is a cornering tool for slightly rounding edges.

Hammer, Nailing, etc.

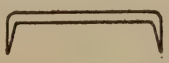
202. Hammer and nails. The common claw hammer has the face, which strikes the nail, either flat or slightly rounded ("bell-faced"). The latter is less likely to dent the wood.

Use a heavy adz-eye hammer for heavy work and a light hammer for small, light work. There are many special hammers for upholstering, tack-driving, riveting, etc.

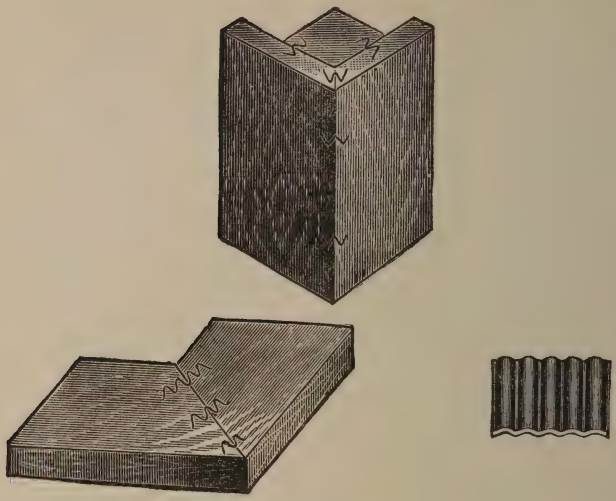
Nails, etc. Wire nails are now used for most purposes. Besides the common ones with flat heads, there are casing, finishing, wrought, cut, brads, etc.[1]

[1] The old terms three-penny, eight-penny, etc., indicate the size.

Distinguish between the nails with broad flat heads and those with smaller round heads. The smaller sizes of the latter are brads. If the nails are to be set (**219**), use round-headed ones, as the flat heads make rough holes. Copper or galvanized nails are best for boat building, copper being preferable, particularly for salt water. Escutcheon pins are used

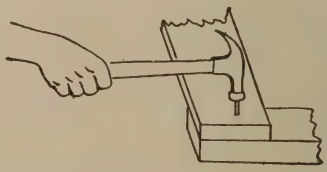


for keyhole escutcheons, small ornamental hinges, etc. *Dogs* hold parts together, as framing timbers, the staves of a built-up column, etc. If the points slant slightly outward (draw-dogs), they will draw the parts together.



Corrugated fasteners are useful.

203. Nailing. Hold hammer near end of handle.[1] Use wrist motion, with some elbow movement. Try to strike squarely on top of nail. Use light blows until nail is started straight.

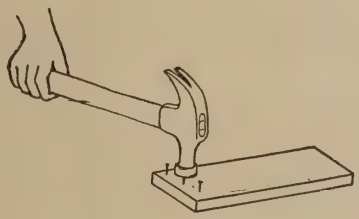


Nails probably hold better when driven home by light blows than by only one or two violent strokes. For rough work, drive the head of the nail flush with the wood. For nice work, stop just before it is flush and drive it in with the nail set (**219**). If the wood be hard, bore a hole slightly smaller than the nail (**208**); also, in soft wood if there seems to be danger of splitting.

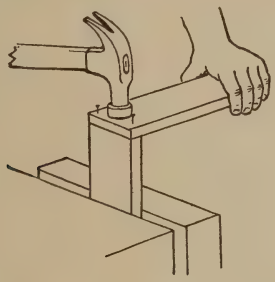
204. Position for starting nails when nailing a box and in similar cases. Place the piece to be nailed on the bench, stand

[1] Occasionally it will do to hold it nearer the head, as in driving very fine brads in delicate work.

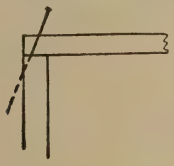
in line with the edge, and drive the nails until the points prick through the wood. For nice work square a light pencil mark

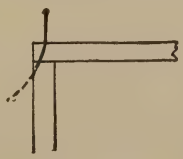


in order to start the nails in line. Avoid nailing very near an end or edge, particularly in thin wood, to prevent splitting.



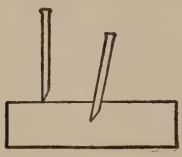
205. Nailing the pieces together. Put one piece in the vise and nail the other to it. By standing in line with the edge as shown you can tell whether you are driving the nails straight, so that the points will not come out through either side of the board. If a nail is driving badly, pull it out and drive in another place. If a nail becomes bent, pull it and use a straight one. Keep face of hammer head free from glue or oil.





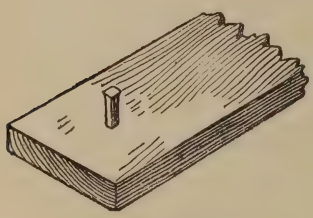
206. Showing nail slanting so that it will come out at the side. Pull it, and if straight drive in another place. If bent,

use a straight one. It is natural in such a case to tap the upper part of the nail until it is vertical or in the line you wish it to go; but if this bends the nail, as often happens, it will be even more likely to break through the side than before, as shown.

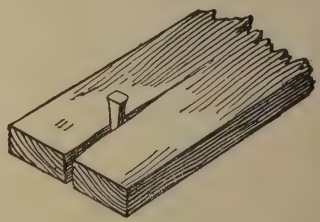


207. **To drive a nail in a slight curve,** on the principle just shown, file the end like a common chisel and the point will tend to work off toward the straight side (83, footnote). To drive in a sharper curve, bend the end of the nail more or less and it will drive in a curve. Try on a waste piece.

208. **Bore holes for the nails for the best work.** A nail holds better when driven in a hole slightly smaller ($\frac{1}{32}''$ to $\frac{1}{16}''$) than its diameter than when driven without a hole. Use longer nails for driving into end-grain than for side-grain, because end-grain does not hold nails so strongly as side-grain. For box work and in similar cases, the length of the nails should be somewhat more than twice the thickness of the board holding the heads.



RIGHT

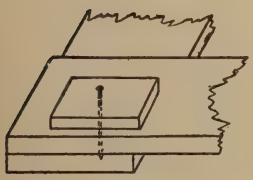


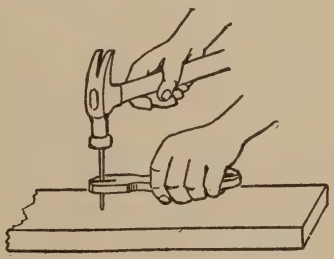
WRONG

209. **Nailing cut nails.** These taper on two sides and should be driven so that their wedge shape cannot split the wood. You can tell how to place them by feeling, for two sides are smooth and go with the grain of the wood. Cut

nails are best for shingling, unless you use galvanized wire ones.

210. Cement-coated nails hold better than smooth ones. Smooth nails hold better than barbed ones.





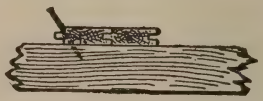
211. Driving slender nails in hard wood. The safest way is to bore holes slightly smaller than the nails (**208**). Touch the points to paraffine or wax, which some keep in a hole in the end of the hammer handle. Soap will do but may cause rust. Holding the nail between three fingers or with pincers sometimes helps. In extraordinary cases a nail can be driven through a waste block of soft wood first, and, when driven as far as possible, the block can be split off and the nail driven home.[1]

BLIND NAIL TOOL

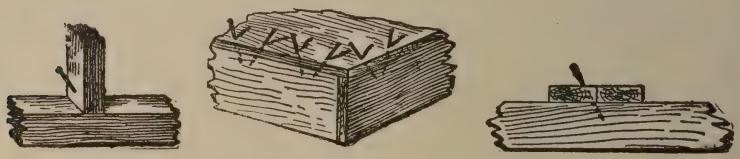
212. "Sliver" or secret nailing. Raise a shaving with narrow gouge or chisel, or use the blind nail tool shown, which can be attached to a ¼″ chisel. Drive the nail in the depression, apply hot glue, and rub the shaving back into place with the face of a hammer, or with sandpaper over a block, until stuck.

[1] In an emergency, if you cannot bore a hole, a wire nail or brad may be less likely to split the wood if you cut off the end, sharpen it on two opposite sides like a brad-awl (**191**), and drive with edge across the grain.

213. Staggering. In nailing cleats, or in similar cases, "stagger" the nails, that is, arrange them in a zigzag way (366). This usually distributes them to the best advantage, enables you to use more nails, and lessens the danger of splitting the wood. This also applies to screws.

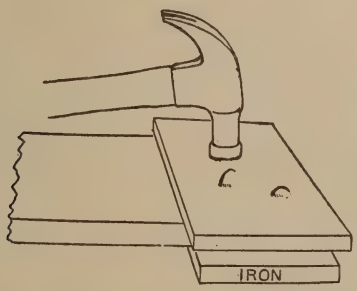


214. Blind-nailing leaves no holes on the surface, as in floors of matched-boards. Each board is nailed slantingly just above the tongue. This holds it down and also draws it toward the adjoining board. The grooved edge of the next board conceals the nailing. See *Floor-laying* (421), *Sheathing* (525).

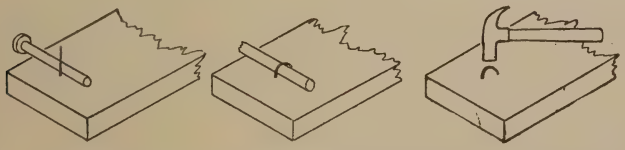


215. Toe-nailing. Driving on a slant. Sometimes there is no other way to nail. Studs in house-building are fastened to the sills by toe-nailing. Sometimes toe-nailing is done to increase the strength, as in the box shown above; but experiments at the Forest Products Laboratory show that, contrary to common belief, slanting the nails does not add to the strength in such cases, except when the wood finally becomes considerably dryer than it was at the time of nailing. Toe-nailing draws two pieces tightly together, as shown (at the right), and in blind floor nailing (421, or sheathing, 525). Sometimes the effect can be increased after the nail has been driven part way by drawing the hammer in the direction of the point of the nail so as to bend the upper part of the nail toward the other piece. In boarding a building, and in similar cases, drive the first nails in each board slanting downward,

and near the top edge, to force the board tightly against the one below.



216. Clinching. After driving through the wood, place so that the head of the nail rests on a piece of metal. Use light, slanting blows to bend the point into a hook. Then bury the hooked end in the wood. Useful in rough work, as for cleats on a shed door. Clinching nails can be bought. For light work, another hammer can be held against the head of the nail, after driving the nail through the wood. For heavy work use something heavier. It is not a good plan to drive and clinch in one operation. Drive the nail through first, then clinch. In such work as canoe-building, however, driving and clinching are done in one operation over a metal-covered form.[1]

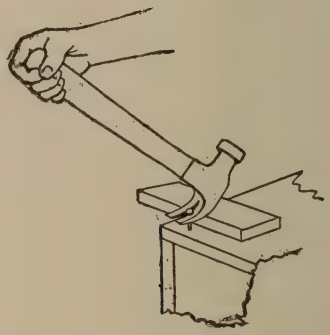


217. To clinch a common wire nail neatly, bend the end around a nail set, round spike, or other rod, with the hammer,

[1] A *rivet*, which holds on the clinching principle, is a pin of metal with a head, especially useful in boat work. Bore a hole for the rivet, drive it through, hold a hammer or solid piece of metal against the head, and pound down or "upset" the other end to form a second head. A washer or "burr" is slipped over the end of the rivet before upsetting it.

remove nail set or spike, and complete the clinching with the hammer.

218. Drawing a nail. Place a block under the head of the hammer. Add more blocking, if necessary, as the nail comes out. To draw nails from boxes, and in similar cases, if you have no nail-puller, pry up a board, together with the nails, a short distance—perhaps ¼″—and then with a quick blow of the hammer pound the board back into place, striking between

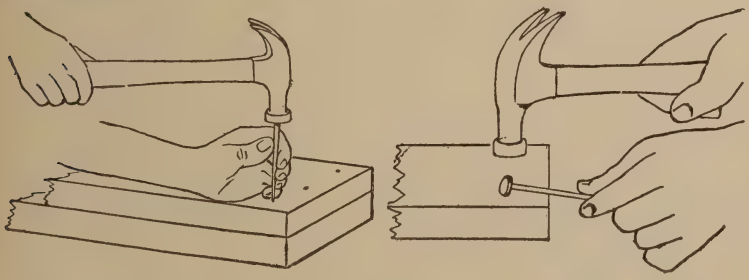


the nails. This will usually leave the nail-heads projecting a little above the surface, ready to be drawn. This lessens the splitting of the boards and the bending of the nails caused by prying and pounding. If you do not need the entire length of the boards, saw around the box near each end. This is less likely to split the boards. Old broken nails can sometimes be removed by boring around them with a quill-bit. Sometimes they can be driven through with less injury to the work than to draw them.

Nail Set

219. Nail set. Used to sink nails below the surface before puttying, etc. The size should depend on the size of the nail. Place the little finger on the wood and also press it firmly against the nail set to keep it from slipping off the head of the

nail. A conical depression in the point of the set helps. On rough, heavy work the head of a large nail or spike can be used if necessary.



Summary. Hold hammer near end of handle, usually. Try to strike head of nail squarely. Bore hole slightly smaller than the nail for nice work, particularly with slender nails in hard wood. Stand in line with edge of piece into which nail is to be driven. Start nails in outer piece before placing in position, when practicable, for nice work. Draw nails which bend or slant when driving, and drive others. Nails hold better in side-grain than in end-grain. Drive cut nails with points across the grain. Stagger nails when practicable. Blind-nailing leaves no holes and draws the parts together. Toe-nailing draws parts together. When clinching drive through, then clinch with light, slanting blows. Use blocking under hammer head when drawing nails. When setting nails keep little finger on the wood against nail set.

Mallet

220. Mallet. Used for striking wooden tool handles, etc. (**348, 469**). "Wood to wood, metal to metal," is the rule when much heavy work like mortising (**467,** etc.) is done with mallet and chisel. Heavy mallets should have the handle put through a tapering eye in the head (**469**). Rubber mallets are sometimes used in assembling work. A rounded head with the

handle on the end (348) saves effort, as there is no flat side to keep adjusted to the tool handle. You do not gain force by using the mallet instead of the hammer, but the softer and more yielding blow saves the tool handle. Hickory, lignum vitæ, maple, or other dense hard wood, is suitable for a mallet. See Chisel (83)

Screwdriver, Screws, etc.

221. **Screwdriver.** This should end in a long bevel or it will slip out of the slot in the head of the screw.[1] A long screwdriver is better than a short one, usually.

222. **A screwdriver bit,** to use with the bit-brace (161), often saves time and strength. Turn the brace part way,

stop, then turn again, and so on; or use the ratchet-brace with only partial revolutions.

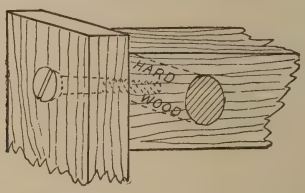
223. The *spiral screwdriver* saves time and strength. It drives or withdraws screws either by pushing on the handle or by a ratchet movement. Can also be made rigid, like a common screwdriver. A countersink can be used in place

[1] A short bevel is also bad when extracting screws, because it necessitates pressing hard against the screw to keep the screw-driver in the slot.

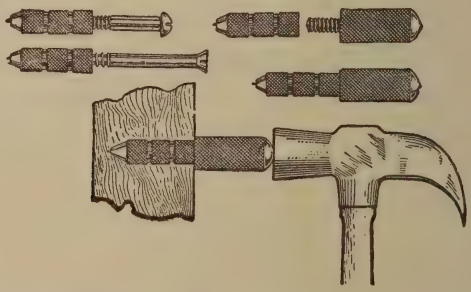
of the screwdriver. The ratchet screwdriver also saves time and strength. You merely turn the handle forward and backward, without having to take a new grip at each turn.

224. Screws. To fasten with screws. Bore a hole in the outer piece—the one which will come against the head of the screw—large enough to let the smooth part of the screw slip through easily without being loose (**182**). Then, when the screw is driven into the inner piece, the head will draw the two parts together tightly. In soft wood the hole in the outer piece is the only one needed, unless there be danger of splitting the inner piece. In hard wood bore a hole in the inner piece somewhat smaller than the diameter of the screw,—sometimes even as large as the core or solid shank if the threads were stripped off. For nice work, if several screws are to be in line, make a light pencil mark on which to bore. Staggering is often best (**213, 366, 367**). When fastening hard wood and soft wood together, drive from the soft wood to the hard, when possible, so that the thread of the screw is in the hard wood and the head bears against the soft. Slender screws (particularly brass ones) are likely to twist off in hard wood, unless the holes are the right size. Countersink for the heads, except for rough work in soft wood and for round-headed screws. Stop turning a screw in soft wood when it is driven home, or you may strip the threads which the screw has made in the wood. These threads in the wood are what make the screw hold. If they are stripped, the screw has less holding power than a nail. Driving a screw with the hammer prevents the screw cutting the thread in the wood, but there is no harm for common work in starting a screw with a light tap of the hammer. Screws do not hold strongly in end-wood, because the thread in the end-grain is easily stripped. Putting glue in the hole may help sometimes. Screws hold more strongly than nails

(except in end-grain, where nails are often better) and the work can be taken apart more easily or tightened; but they cost more, take more time, and sometimes they injure the appearance of the work. To make a screw drive easily, rub the point on paraffine or wax. Soap will do, but may cause rusting. To replace a screw in a worn hole, or if a hole is in the wrong place, if not to be exposed to the weather first plug the hole with a peg tightly fitted and driven with glue. If exposed to the weather, try waterproof glue. Winding wire around the thread is sometimes done as a makeshift. When one-half of the head of a screw breaks off in driving, the screw can often be drawn out by gripping the remaining half-head in the claw of a hammer, and turning the hammer around to the left.



225. **Inserting a dowel,** or other piece of hard wood, across the grain, to give a stronger hold when a screw has to be driven into end-grain. Use care not to split the dowel.



226. **"Screw holes."** When screws have to be removed and redriven frequently in the same place, "screw holes" can be used to advantage.

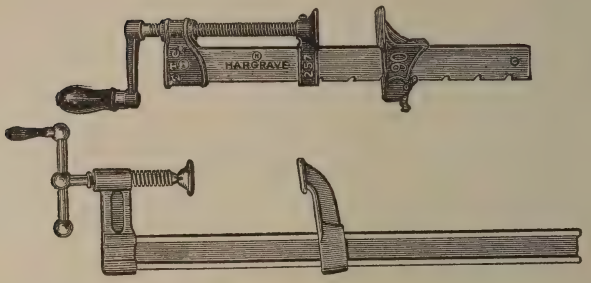
227. Screws are of various kinds.[1]

Summary. End of screwdriver should have long bevel. Screwdriver bit good for common work. Spiral or ratchet screwdriver very convenient. To fasten two pieces, bore hole in outer piece so that screw will just slip through. Small hole in inner piece, if hard wood. Staggering often desirable. Screw soft wood to hard, rather than the reverse, when practicable. Countersink for heads of screws, except for rough work in soft wood and for round-headed screws. Overdriving screws, or pounding them in with a hammer, strips the thread cut in the wood. Screws do not hold strongly in end-wood. With slender screws in hard wood, size of hole in inner piece must be carefully adjusted to size of screw. Touch points to paraffine, wax, or soap. Plug a worn hole (or one in the wrong place) with wood. For greater strength, use bolts or rivets.

[1] The size is indicated by the length in inches or fractions of an inch, and by the size of the wire from which the screw is made, as a 1½″ screw No. 9, meaning one and one-half inches long and made from No. 9 wire. Wood screws are made from ¼″ to 6″ in length and of wire from 1 to 30. Some screws for rough work are made to be driven with the hammer, the screw driver being used only to finish the driving.

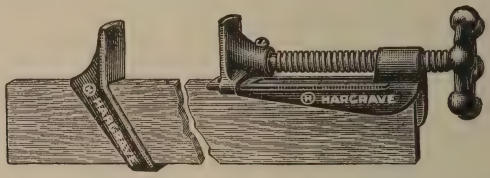
Lag-screws, screwed in with a wrench, are useful for frame-work, as a bench, and for fastening metal to wood. A washer should be used sometimes next the head if against wood. *Bolts* hold much more strongly than screws, and should be used when strength is the main object, as in a gate, bob-sled, heavy horses, some kinds of boat and wagon work, etc. A bolt should fit the hole snugly. A washer should be used under the nut when it comes against the wood, and sometimes under the head. Bolts in outdoor work should not be screwed up so tightly as to make depressions in which water may settle and cause decay. The length of a bolt is measured from the point to the underside of the head, therefore in selecting you must allow for the thickness of the nut, and for washers if the latter are used. Common kinds of bolts are carriage, stove, and machine. To prevent a nut unscrewing, use a lock-nut, or deform the thread if the nut will not be removed. Rivets are also used for some kinds of work. To fasten wood to masonry, an expansive bolt can be used.

Clamps, Handscrews, etc.

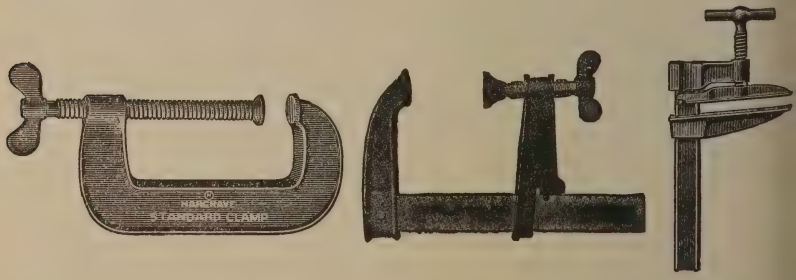


228. Clamps. Cabinet-clamps are important for gluing flat pieces together and in assembling large work like furniture.

229. Type of clamp for heavy work. If mounted on horses, or on permanent supports, two or more of such clamps are

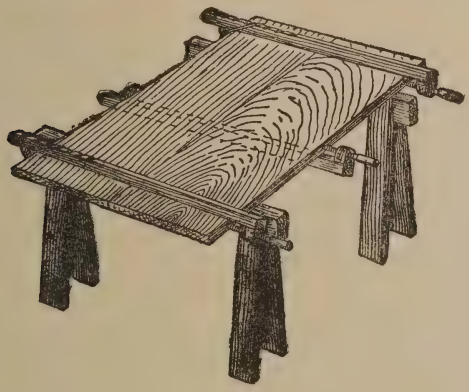


invaluable for quick and accurate clamping of large work like doors, table tops, etc. To make a long clamp, in an emergency, bolt together the bars of two clamps so that there will be a screw at each end.

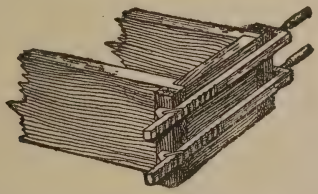


230. Convenient forms of clamps for general use.

231. Clamping a glued joint. The flat sides or the edges of the clamps should touch the surface of the work, to keep the pieces flat when the screws are tightened. Clamps are



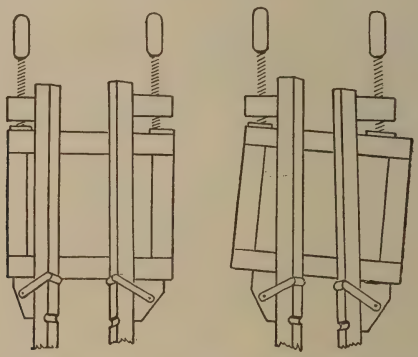
also made with two bars, one to bear on each side of the wood. Screw each clamp in turn a little at a time, so that the joint may be brought together evenly.[1] Two persons can use cabinet clamps to the best advantage. See **146.**



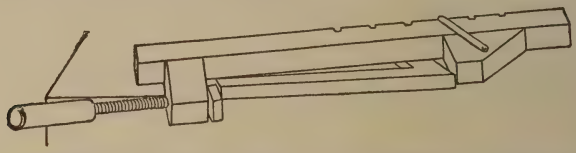
232. Put pieces of waste wood between the clamps and the work.

[1] Unless the pieces are firmly clamped throughout, their shape may change before the glue becomes set. Clamping at only one or two points may force the joint to open elsewhere. First make the best joint you can. Then, after gluing, hold the pieces together with a good number of clamps, firmly and evenly tightened. The old-fashioned way of rubbing the two edges together and then leaving the rest to the glue is not so good for the beginner as to use clamps, except with small pieces, such as corner-blocks (450).

233. **In assembling work,** as the clamps are tightened and the joints brought to a bearing, test to see that everything is coming square and true. Test by eye, with square, etc., because the pressure of the clamps, unless they are in exactly the right position, often forces the work out of shape, even though the parts may have fitted properly before applying pressure. By loosening a clamp a little and moving one end upward or downward, or to the right or left, and then tightening, the work can be made true and square. Move one end of a clamp and then test, and you will soon see how easily the angles of the work can be altered until correct. Merely moving the blocking, or inserting a slip of wood, is often sufficient to change the angle. Sometimes a slight blow at one corner will make the work square. A clamp placed diagonally can be used if necessary (**308**).

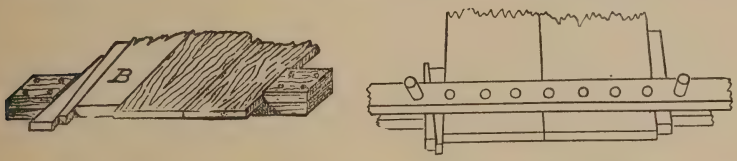


234. **Moving one end, or both ends,** of each clamp to the right or left to make the angles correct.

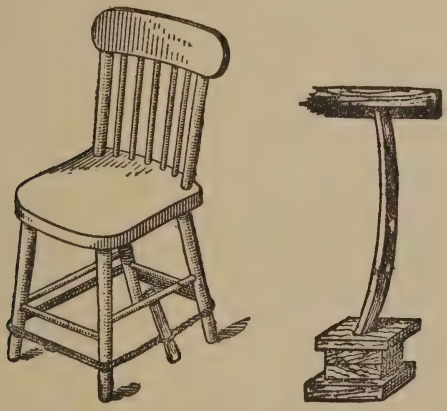


235. **Moving end of clamp up or down** to make the surface flat.

236. Simple devices for clamping, tightened with double wedge (**247**). Insert waste wood (B) if clamp is too long.



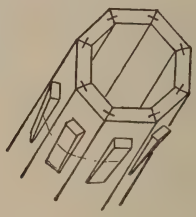
The first form shown can be made double by putting blocks on the under side also. The second form has two strips with corresponding holes in each and pins to fit them. It has the advantage of preventing the pieces from springing up when the wedges are driven.



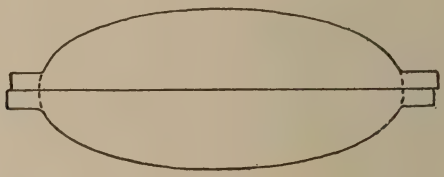
237. A doubled rope ("twister"), with stick inserted and twisted, is very effective in some cases. Sometimes force can be applied by springing a board. For small work a press can easily be made, obtaining the pressure with a screw or by a weighted lever. Pressure by a toggle-joint is very powerful. See **422, 423.**

238. For columns built up of staves there are special column clamps. In such cases a "twister" (**237**) can sometimes be used. A chain, wire, or strong rope can be loosely wound

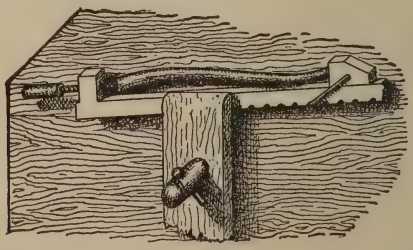
around the column, and wedges driven between the column and the wire, rope, or chain, which will force the parts together



tightly. Draw-dogs (**202**, footnote) can be driven into the ends, or corrugated fasteners (**202**) for small work. See **545**.

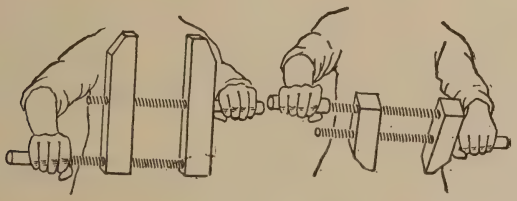


239. When gluing pieces of such a shape that the clamps will not hold readily, as in the example shown, leave projections or lugs at the ends to receive the clamps, and trim them off after the glue is hard; or better still, glue the pieces together before cutting the shape.

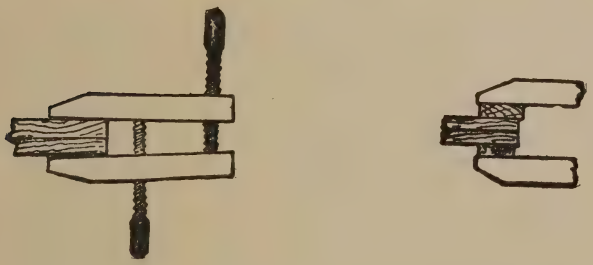


240. Suggestive of uses to which cabinet clamps may be put.

241. Handscrew. A kind of portable vise, often used for pressing glued work, and for holding parts of work in place.

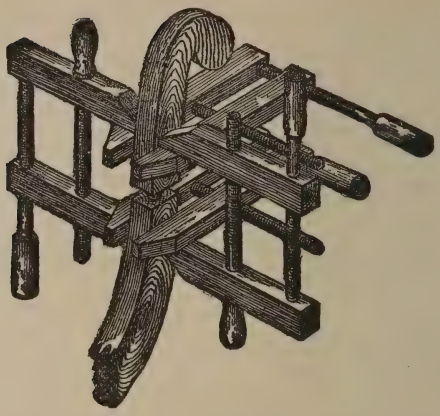


242. Opening or closing a handscrew. First see whether the jaws are parallel. If not, turn one of the screws until the jaws are parallel. Then hold at arm's length, with a handle in each hand, as shown, and revolve. Revolving one way opens the jaws, the opposite way closes them.

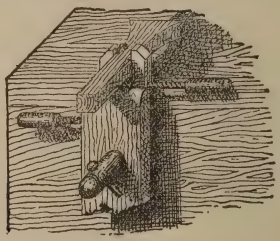


243. Adjusting handscrew to the work. Fit the handscrew so that the tip ends of the jaws do not quite touch the wood, as shown. Then give the final tightening with the outer screw only, until the jaws bear on the wood evenly. For nice work use blocking of waste wood, as shown, to prevent bruising the work. Keep the jaws clean. Rub the threads of the screws with black lead, soap, bayberry tallow, or wax.

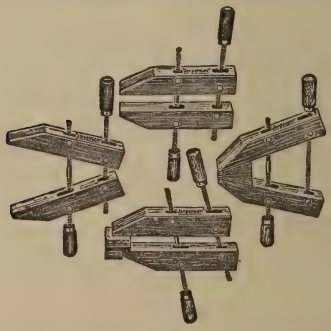
244. Suggestive of various uses of hand-screws for clamping in different directions at the same time. Chalk rubbed on



the jaws makes them less likely to slip when pressure is applied by a second hand-screw.

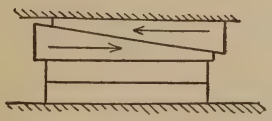


245. **Suggestive of uses** to which hand-screws may be put.



246. **Useful for irregular work.** Jorgensen clamp.

Summary. Tighten clamps, etc., carefully to give uniform pressure. Use blocking to save defacing the work. For edge-joints have bars of clamps bear on the surfaces to keep them flat. In assembling, move ends of clamps to the right or left, or up or down, if necessary, to make the work square and true. Keep testing by eye, with square, by diagonal measurements, etc. Work quickly. Where a number of parts are to be glued at once, rehearse the clamping process before applying glue. Substitutes for clamps easily contrived. Make jaws of hand-screws parallel, then adjust, and finally tighten with outer screw.



247. Wedges. To split, use one wedge (**75, 578**). To press, hold, or move, use a double wedge; that is, two wedges pointing in opposite directions, so that the pressure will be uniform, whether one or both wedges be driven. Short, flaring wedges do the work quickly but require hard blows and are liable to slip. Long tapering ones work more slowly, more easily, and are less liable to slip. A single wedge may damage work where a double one will not.

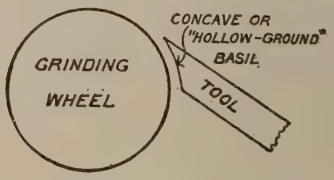
SHARPENING

248. Usually two operations: first, *Grinding*, to make the bevel[1] for the edge; and second, *Whetting*, to make the edge sharp for cutting. While learning, examine the edge with a magnifying glass, now and then.

249. Grinding. Grinding wheels of artificial quick-cutting abrasives are in common use. They cut much faster than the old-fashioned grindstone, though it is doubtful whether the

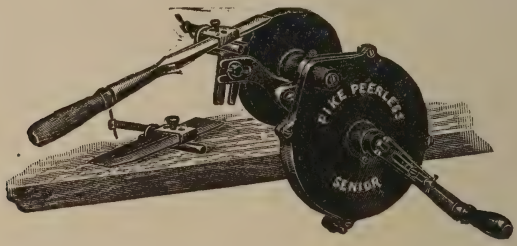
[1] This bevel is the *basil* of the tool.

result is better. The tool is held steadily by adjustable guides, and the small size of the grinding wheel gives a concave or "hollow-ground" basil. This makes a thin and keen cutting



edge, which lasts longer without re-grinding than if the basil were flat (**253,** footnote). Power-driven oilstone grinders are in common use, and are desirable. For heavy mortising, or rough work in hard wood, a flat basil is better, because stronger.

250. To grind a plane-iron, chisel, spokeshave, etc., with a grinding wheel. If a plane-iron, remove the cap-iron (**133,** footnote). Have the wheel turn toward you. If the edge of



the tool is not square, first make it so by grinding the extreme edge, testing with square. Then set the adjustable guide to grind the basil at the angle it had at first, as nearly as you can.[1] Then grind the basil. Keep the tool moving sideways,

[1] Guides for grinding and whetting (**252**) plane-irons and chisels can be obtained.

Although the angles should be varied slightly according to the hardness of the wood and the kind of work, where there are only a few tools to be used for all purposes, it is not practicable to vary the angles much unless there is considerable work of the same kind to be done. Experience will teach the best angles for different kinds of work. An edge suitable for delicate work

all the time, for if you grind long at one point the temper of the edge will be injured. The tool can be dipped in water. Grind until the basil is formed evenly to the edge. It will then be properly shaped but will not be sharp. Most common cutting tools are ground in this way. To hold the iron of a spokeshave, insert it in a narrow slot cut in the end of a piece of wood.

251. To grind with a grindstone. The principle is the same as just shown. Have stone turn toward you. Keep it wet, or the temper of the tool will be injured and the stone glazed.

Hold tool so as to grind at the original bevel, as nearly as you can (about 25°,—usually from 20° for light paring tools to 30° for heavy mortising tools to be used in hard wood.) Keep the arms near the body. Hold the tool firmly and move it slowly sideways, back and forth, across the stone, with the fingers, or the palm, of the left hand on top of the tool. Test squareness of the edge with square. A rest for the tool, easily contrived, helps to keep it at the same angle. Grind until the basil is formed evenly to the edge.

252. Whetting. After grinding, rub on an oilstone. Artificial stones of carborundum or other manufactured abrasive are in common use, because they cut faster than natural stones, though it is doubtful whether they give a better edge.

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in white pine would be ruined quickly if used upon lignum-vitæ. The fibrous structure of soft wood, being more yielding than that of hard wood, offers less resistance to the tool, and therefore requires a keener edge to cut it cleanly without tearing or crushing the wood. The firmer structure of hard wood can be cut by an edge which would merely tear the soft wood.

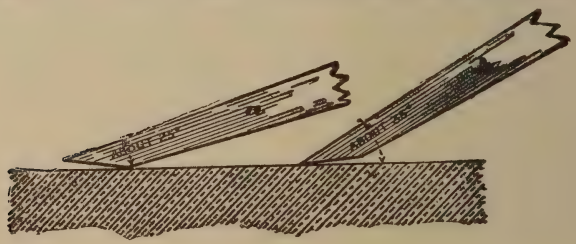
For tools requiring an extremely fine edge the natural Arkansas stone is unsurpassed, while for common tools the Washita is still desirable for giving a very durable edge. An artificial oilstone with one side coarse and the other fine is excellent. Use oil with artificial stones and also with fine and medium-grained natural stones, to prevent the pores being filled. Use water with coarse natural stones. A worn stone can be trued by rubbing on sand paper, with water, or on wet sand on a board.

253. To whet. Pour a little light lubricating oil on the stone.[1] Lay the basil of the tool on the stone as you had it when grinding. Raise the rear end of the tool *very* slightly until you can see the oil press up a little in front of the edge.

Then rub the edge backward and forward at the same slant until you have ground a little basil.[2] The tool can be turned

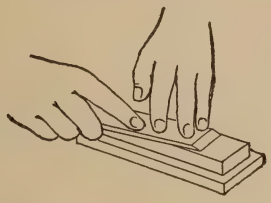
[1] Do not use linseed, or any thick gummy oil, as it will gum the stone.

[2] Flat basil made by grindstone is shown by *a*. Position for rubbing on oilstone by *b*. With a small grinding wheel, the ground basil will be



concave, as already shown (249), so that the tool must be raised but very slightly for whetting.

obliquely and rubbed back and forth. Round the corners a very little. After whetting there will be a "wire-edge" turned over on the flat side. You can feel it.

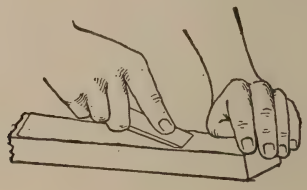


254. Removing wire-edge. Lay the flat side of the tool on the stone and draw it toward you, or sideways, once or twice. Keep it *flat on the stone*, for the slightest basil on the flat side will spoil the edge. Repeat the whetting and the removal of wire-edge, until no roughness can be felt. Drawing the edge lengthways across a piece of soft wood will often remove a very slight wire-edge. Keep the stone clean.

255. Testing sharpness. Pass the thumb lightly along the edge. You can feel the slightest roughness. Also test by cutting across a piece of soft wood. Hold the edge toward the light. A sharp edge is invisible to the naked eye; therefore, if you can see a bright line at the edge, continue sharpening until it disappears.

256. Stropping. Drawing tool over a leather strop for a very fine edge. Draw the tool backward over strop. Raise,

and repeat the motion. Stropping is necessary only for fine work, carving, etc. A paste of lard or sweet oil and crocus



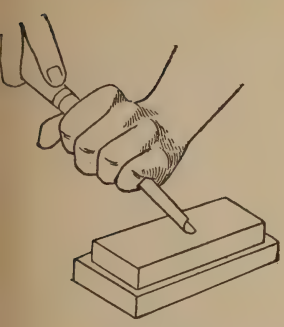
powder or emery is spread thinly over the strop. Strops treated with fine artificial abrasives can be bought.

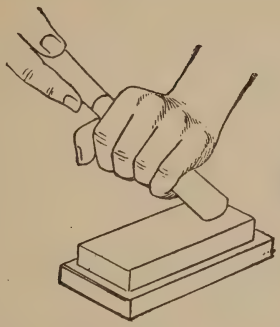
257. **Re-sharpening.** You do not need to re-grind the edge when it becomes only slightly dull. Whet it on the oil-stone. After doing this several times, you will have to grind again.

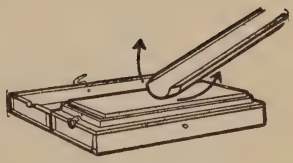
258. **Knife.** In grinding, tilt the blade very slightly so that the cutting basil lies flat on the stone. Grind equally on both sides. To whet, hold the blade obliquely on the stone, tilt it slightly so that the basil rests on the stone, and rub it back and forth. Do the same on the other side, and so on. Finish with a fine stone, and with strop for a very keen edge. Some use a circular motion near the point, and let the straight part bear a little harder on the edge of the stone than elsewhere, as it is pushed back and forth.

259. **Gouge.** Turn or roll the tool continually while grinding.[1]

[1] "Hold the length of the gouge, not parallel with the face of the wheel but at right angles so that the bevel is ground sidewise and rock the entire







260. Rub on oilstone like plane-iron or chisel, but roll continually. Can be held at right angles with the stone and rolled.

SLIP STONE

261. Whetting edge of outside gouge with slip-stone held in the hand, using oil. The inside gouge is best ground on a tapering, conical-shaped, artificial stone.

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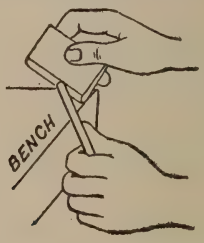
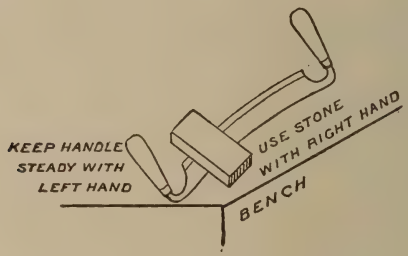
surface of the bevel back and forth on the face of the wheel. A shows the result of good, accurate sharpening, while B indicates the irregular bevel-

angle caused by attempting to sharpen a gouge without enough of the rocking movement."—*Pike Manufacturing Co.*

262. Whetting basil of "inside" gouge with "slip." The curvature of the slip should be a little "quicker" (sharper) than that of the gouge. Rest the tool on the edge of the bench



and move the stone, not the tool. Carving gouges are usually held in the hand for rubbing. Remove wire-edge from outside gouge in the same way, but keep the slip *flat* against the inside of the gouge, to prevent making an inside basil, which would spoil the edge.

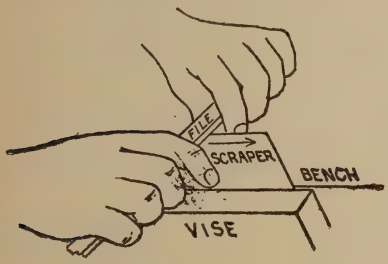


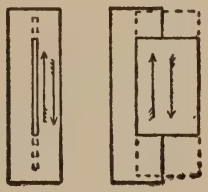
263. Drawknife. Grind like the plane or chisel. To whet, hold on the bench, basil side up, as shown, and whet the edge with the oilstone, rubbing lengthways of the stone.

264. Bits. File the scoring nibs (**162**) of the auger bit from the *inside* only, or they will score a circle too small for the rest of the bit. There are special files for auger bits. A slip-stone can also be used. File the cutting-lips (**162**) from the under side. Hold bit, with point up, against edge of bench when filing, as shown in **262**.

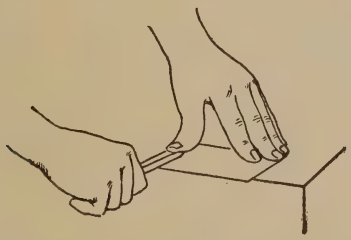
Twist-drills are ground on the ends, at the same angle as at first. Do this on the side of the tool grinder.

265. Cabinet scraper. Drawfiling edge. Fasten in vise, one long edge upward. Hold file (for metal) as shown, and





move it lengthways of the edge a few times. Do this with the opposite edge also. The edges can be ground on a grinding wheel. The edges and sides can then be rubbed lightly on an oilstone to remove any burr or roughness, as shown at the right.

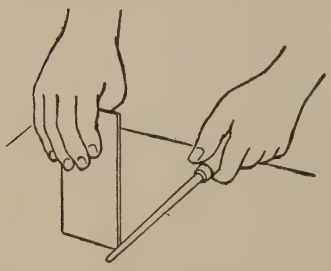


266. Rubbing with burnisher. Next, lay flat at edge of bench. Take burnisher,[1] place it flat on the scraper, and rub each edge lightly back and forth a few times to make the edge keen for turning.

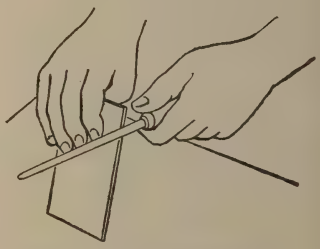
267. Turning the edge. Rub the burnisher with a firm, light, even stroke once or twice, lengthways of the edge, at the same time giving a lengthways motion, from tip to handle.

[1] The burnisher is a piece of hard, smooth steel of triangular or curved section and rounded edges. One can be made easily by grinding an old triangular file until smooth. The edge of the blade of a chisel or the back of a gouge can be used if necessary, but a burnisher is better.

The movement is similar to that in making a shearing cut with an edged-tool (77). This helps turn the edge. Treat the



BEGIN IN THIS POSITION



END IN THIS POSITION

four long edges in this way. When all four edges are dull they can be re-sharpened once or twice with the burnisher. Then they will need drawfiling again. Some grind the edges at a bevel, using one angle instead of two, but this is of doubtful advantage.

268. Brad-awl. Sharpen with file (for metal), or slip-stone.

269. Trimmer. A keen edge is necessary. The knife must be sharpened entirely on the bevelled side. To remove any wire-edge, use only the merest touch of a fine oilstone on the flat side, giving a final touch of the stone on the side of the basil.

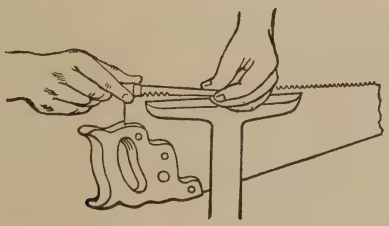
Summary. Two main operations—grinding and whetting. An artificial grinding wheel saves time, compared with a grindstone. Use water with the latter. Have the wheel turn toward you. Hollow-ground basil preferable, except for rough work in hard wood or heavy mortising, etc. With plane, chisel, etc., first grind edge square, then grind the basil. Avoid injuring the temper of the tool. Basil of medium length for general work, long for fine work in soft wood, short for rough hard work. Whet to make a second small basil at edge. When removing wire-edge, keep flat side of tool *flat* on the stone. Use lubricating oil with an artificial whetstone (water with a coarse natural stone only). Test sharpness with thumb, and

by cutting soft wood. A keen edge is invisible to the naked eye. For very fine edge use strop. Roll outside gouge when sharpening. Whet gouges, etc., with slip stone. File auger bits on the inside and under side. Grind a twist drill on the end. Drawfile scraper, and turn edge with burnisher.

SAW-FILING

270. Saw-filing. A trade in itself. Many good workmen turn over the care of saws to professional experts. There is usually at least one saw-filer in nearly every community.[1]

Summary. Top-jointing, setting, filing, side jointing.

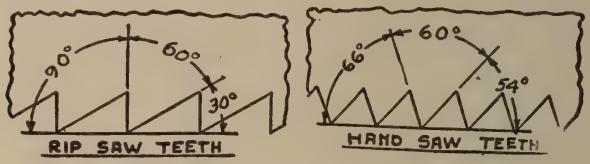


[1] The teeth are first "jointed," or reduced to the same level, by lightly passing the flat side of a file over their points, lengthways of the saw. The saw is firmly fastened in a saw-clamp, close to the teeth, so that it will not shake or rattle, preferably at a north window, on account of the light. The teeth are set by bending them outward, one tooth toward one side and the next toward the other side. Do this with a "saw-set." A tooth should not be bent for more than half its length. For a cross-cutting saw the file (a triangular saw-file) is held at an angle with the blade to fit the original shape of the teeth.

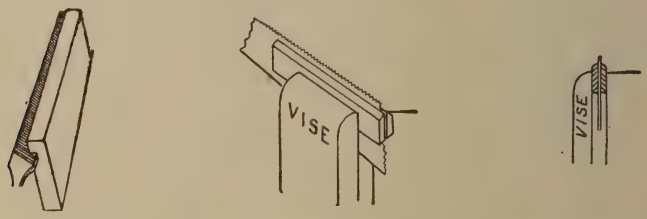
Hold the handle of the file in the right hand and the point between the thumb and forefinger of the left hand as shown. Push the file across with an even, straight stroke, without any rocking motion. Press only on the forward stroke and lift the tool on the back stroke. File from the handle toward the point (some begin at the tip), filing only the teeth which bend away (*i. e.*, every alternate tooth), and carefully keeping the file at the proper angle. Press only on the tooth being filed, but keep the file lightly touching the adjacent tooth, and make allowance for the fact that when the alternate set is filed the file will take off a little from the first set of teeth.

Thus care must be taken not to file too much. Then turn the saw around and file the other teeth. On looking lengthways along the edge of a cross-cutting or panel saw that has been properly set and filed, an angular groove will be seen along the whole length, in which a needle will slide from one end of the saw to the other. After setting and filing, lay the saw on a straight board and joint the sides of the points of the teeth by running a smooth file or oilstone along the sides of the teeth. Thus the width will be more uniform and the cutting cleaner.

The ripping-saw is usually filed square across at right angles to the blade. A soft saw with large, well-shaped teeth is best for practising filing, and the beginner can try first on a piece of soft sheet metal.



("Angles. The 'face' of each cross-cut tooth is slightly steeper than the back, making an angle with the line of the teeth of about 66°. The compass teeth lean still further with an angle of 75°. The rip saw 'face' is at right angles (90°) to the line of the teeth. Its cutting edge is at right angles to the side of the blade. The angle of each tooth covers 60°." *Simonds Manufacturing Co.*)



If you cannot hold the file steadily, use a jointer, which can be bought, or make one, as shown. If you have no saw-clamp, use two hardwood strips and fasten in vise. The teeth of the compass saw are a compromise between cross-cut and ripping teeth. The turning saw usually has ripping teeth. As little set as will allow the saw to slide freely through the wood is best. Guides for saw filing can be bought.

QUESTIONS

EDGED TOOLS. 1. *Show the difference between the action of edged-tools when splitting and when paring.*

2. *What is a shearing cut? Why often more effective than a straight cut?*

KNIFE. 3. *From what direction should the light come when whittling?*

4. *What causes the most trouble in doing accurate whittling?*

5. *When whittling a wide surface to make it thinner, where would you cut first?*

6. *What is usually the best position for the arm which holds the work?*

7. *Show how to make a shearing cut.*

HATCHET. 8. *Show the action of the hatchet or axe when splitting wood, and when paring or trimming.*

CHISEL. 9. *Show how to control the chisel for paring, trimming, and shaping.*

10. *How can you tell in which direction to cut?*

11. *When should a chisel have a long basil?—a short basil?—one of medium length?*

12. *Show how to make shearing cuts—to trim the edge of a dado or groove—. to pare across end-grain.*

13. *Show how a common chisel acts when held upright and driven into the wood. Show how a carving chisel acts when driven in the same way.*

GOUGE. 14. *When should you use an outside gouge?—an inside gouge?*

15. *Show how to control the gouge to make a shearing cut.*

16. *What is usually the best way to cut to remove surplus wood?*

17. *What is a "quick" gouge?*

DRAWKNIFE. 18. *What are the uses of the drawknife? Do you find it a hard tool to use? If so, why?*

19. *Show how to make a shearing cut.*

20. *When should the basil be used against the wood, and when the flat side?*

SAW. 21. *What are the two common kinds? For what is each used?*

22. *What is the set, and for what purpose?*

23. *Show the shape and action of the teeth of the cross-cut saw.*

24. *What familiar tool does each of the teeth resemble in its action?*

25. *Show how to place the wood for sawing, the position to take, and how to hold the saw.*

26. *Show how to start the cut in the right place, to begin the strokes, and to continue the sawing.*

27. *Show how to saw with regard to the line and the waste wood.*

28. *Show what to do if you are not sawing squarely with the surface—also, if the saw runs off the line.*

29. *Show the shape and action of the teeth of the rip saw.*

30. *What common tool does each of the teeth resemble in its action?*

31. *Can you use the cross-cut saw to saw with the grain? Is it ever desirable to do so? Why? What is the result of using the rip saw across the grain?*

32. *Does this saw cut on the forward stroke, the backward stroke, or on both?*

33. *At what slant does this saw cut to the best advantage?*

34. *If you are ripping a thick piece, show a simple way of cutting to the line on both sides.*

35. *When the kerf closes and binds the saw, what can you do?*

36. *When cutting a piece from the corner of a larger piece, should you first saw lengthways or crossways? Why?*

37. *If you could have but one saw, which would you choose?*

38. *When are a slight set and fine teeth best? When a wider set and coarse teeth?*

39. *When should you use the back saw? Show how to use it. What kind of teeth has it?*

40. *Should the flat side of a piece or the edge be upward, usually, when using the back saw? Why?*

41. *When should you use the compass saw?—the keyhole saw? What kind of teeth has the compass saw?*

42. *When should you use the turning or bow saw? Show how to use it.*

43. *When should you use the hand jig saw, the scroll saw, and the coping saw? Show how to use them.*

44. *Show how to support the wood in order to saw vertically.*

45. *To follow the pattern, when sawing in this way, which do you turn, the wood or the saw? Why?*

46. *Must the teeth point upward or downward? Why?*

47. *How do you saw a hole, or inside openwork, with one of these narrow-bladed saws?*

48. *How do you cut a very sharp curve or angle with one of these saws?*

MITRE-BOX. 49. *When would you use a mitre-box?*

50. *Show how to lay out and make a wooden mitre-box. Also, a simpler form with one side.*

51. *Show how to cut a number of pieces of the same length with the mitre-box.*

PLANE. 52. *If you could have but one plane, what kind would you choose? When should you use the jack plane?—the jointer?—the fore-plane?—the smoothing-plane?—the block-plane?*

53. *When should you remove the planer-marks from machine-planed stock? When is it not necessary?*

54. *Show the arrangement and adjustments of a plane. Show the purpose of the cap-iron.*

55. *Show how to adjust for crooked-grained hardwood.*

56. *How should the cutting edge of the jack-plane be ground for general work?—for merely roughing off the surface?*

57. *Show how to adjust the projection of the cutting edge.*

58. *Explain planing with the grain and against it.*

59. *Show a simple way to support the end of a long piece.*

60. *Planing an edge. What two requirements must be met? What should you do first?*

61. *Show how to hold the plane. Why must you keep it flat on the wood while planing?*

62. *Show the process of planing an edge.*

63. *Why should the plane be kept lengthways of the edge? What advantage might there be in turning it partly around? What disadvantage?*

64. *Why is it best to take long strokes?*

65. *What is the reason for having long planes like the jointer? What disadvantage has a long plane?*

66. *Show how to test the straightness of your planing—the squareness of the edge.*

67. *If one side of the edge is higher than the other, what can you do?*

68. *What is the general process in planing edges to be glued to make a wide surface, as a table-top?*

69. *Show how to arrange and mark the pieces.*

70. *Show the process of jointing the edges. Why reverse alternate pieces for planing?*

71. *Instead of using the try-square to test the edges for a glue-joint, how should you determine the accuracy of the joint? What else must you test?*

72. *Instead of having the edges touch throughout, what is a common practice?*

73. *Before beginning to plane the side of a board or a wide surface, what should you do?*

74. *How should you hold the plane?*

75. *Show how to test the flatness of the surface with the plane or other tool.*

76. *With a rough surface, or when much wood has to be removed, how may you plane at first?*

77. *Show how to plane end-grain. Show several ways. What plane is best for this?*

78. *Is a shearing cut ever advisable with the plane? When?*

79. *Show how to plane the edge of a box at the corner, and in similar cases.*

80. *Show how to make an octagonal stick by planing.*

81. *Show how to make a bead cutter.*

SPOKESHAVE. 82. *When would you use the spokeshave? Show how to use it.*

83. *Why is it not suitable for doing the ordinary work of a plane?*

TRIMMER. 84. *Show the principle of the trimmer, and how to cut with it.*

Boring Tools. 85. *What advantage has the ratchet brace?*

86. *What is the function of the worm or point of the auger bit?—of the scoring nibs?—of the cutting lips?*

87. *Why should pressure be unnecessary when boring with the auger-bit?*

88. *When would you prefer a single thread screw point, and when a double thread?*

89. *How can you tell the size of an auger bit?*

90. *Show how to insert the bit in the brace and how to take it out.*

91. *Show how to bore, and how to test the accuracy of the boring.*

92. *Show how to withdraw a bit from the hole.*

93. *Show how to prevent splintering when boring through a piece.*

94. *When boring a deep hole in hard wood is difficult, what is it well to do?*

95. *How can you be sure that the position of a through hole will be exact on both sides of the piece?*

96. *Show how to bore at a given angle.*

97. *When should you use a bit gauge? If you have no bit gauge, what can you do?*

98. *Show how to adjust and use the expansive bit. If the work is too hard for this bit, what can you use?*

99. *To cut a hole too large for an expansive bit, or if you have no expansive bit, what can you do?*

100. *What is counterboring? When should you do it?*

101. *If you have bored a hole with an auger bit, can you continue it with a smaller bit? Can you continue it with a larger one? Why? What can you do in the latter case?*

102. *What advantage has the twist drill? What disadvantage?*

103. *What advantage has the twist bit for wood? What disadvantage?*

104. *How can you tell the size of a twist drill?*

105. *What advantage and disadvantage has the gimlet bit?*

106. *When can you use the Forstner Bit?*

107. *What advantage has the center bit? What disadvantage?*

108. *When should you use a countersink?—a countersink gauge?*

109. *What are the uses and advantages of the breast and hand drill, the push brace, the small hand drill, the reciprocating drill, the automatic push drill?*

110. *When would you use a reamer?—a screw and plug bit and plug cutter?*

111. *What disadvantage has the gimlet?*

112. *What is the use of the brad awl? Show how to use it. How should the size of the awl compare with that of the nail to be driven?*

File and Rasp. 113. *When should you use the file? Show how to hold it and how to use it.*

114. *Why should you press on the forward stroke, but not on the return stroke? Why press lightly when using a new file?*

115. *Why should you not use a file for wood on metal?*
116. *How do you clean a file for wood?*
117. *What shapes are the most generally useful for woodworking?*
118. *How does the rasp differ from the file? When should you use the rasp?*

SCRAPER. 119. *When should the scraper be used?*
120. *Show the principle upon which it works, and how to use it.*
121. *Make sketch showing the shape of the cutting edge.*
122. *Why spring the scraper at the centre? Why hold it as nearly vertical as it will cut well?*
123. *Is the name scraper strictly correct? How do you test the surface for smoothness?*

SANDPAPER, ETC. 124. *What is the function of sandpaper in hand work?*
125. *Why defer using sandpaper until you are through using cutting tools?*
126. *When should you use a block for sanding?*
127. *Show how to sand surfaces and edges with a block—without a block.*
128. *How can you sand a small end? —a round or curved surface?*
129. *What makes a good block for fine work?—for curved surfaces? Show how to tear sandpaper?*
130. *For what is steel wool useful?*
131. *For fine cabinet work why is it well to round the edges just enough to remove the sharpness?*

HAMMER AND NAILS. 132. *Name two common kinds of claw hammers? How do they differ?*
133. *Show how to hold the hammer, and how to strike the most effective blow.*
134. *What is the secret of good nailing?*
135. *How can you avoid denting the wood?*
136. *When should you bore a hole for a nail? What should be the size of the hole compared with that of the nail?*
137. *Show the position to take when nailing a box, and in similar cases. Show the process of nailing.*
138. *Why is it best to stand in line with the edge being nailed?*
139. *If a nail bends, what should you do?*
140. *If a nail slants so that it will come out at the side, what should you do?*
141. *If you tap the upper part of a slanting nail until it is in line with the direction in which you wish to drive it, what is likely to happen?*
142. *Why use longer nails for driving into end-grain than into side-grain?*
143. *Show how to drive cut nails and why.*
144. *Compare the holding power of cement-coated, smooth, and barbed nails.*
145. *Show how to drive slender nails into hard wood.*
146. *What are the advantages of staggering nails?—of blind nailing?*
147. *Show how to do "sliver" or secret nailing.*
148. *When would you do "toe-nailing"?*

149. *How can you draw two pieces together by nailing?*

150. *When should you clinch nails? Show how to do it? Show how to clinch a common wire nail neatly.*

151. *Explain the terms three-penny, four-penny, etc.*

152. *What kind of nails should you use if they are to be set?*

153. *What kind for nailing a board fence?*

154. *What kind for boat building or exposure to the water?*

155. *For what are corrugated fasteners useful?*

156. *When should you use rivets? How do you drive them? When should you use draw-dogs?*

157. *Show how to draw a nail—how to prevent its bending. Show how to draw nails from boxes, and in similar cases.*

NAIL SET. 158. *When should you use the nail set? Show how to use it, and how to keep it from slipping off the head of the nail?*

159. *How can you set nails in rough work, if necessary?*

MALLET. 160. *When should you use the mallet? How are the handles of heavy mallets fitted?*

161. *What shape of head is usually the most convenient?*

SCREWDRIVER AND SCREWS. 162. *What is the correct shape for the end of a screwdriver? Why?*

163. *When is a screwdriver bit desirable? How can you prevent its slipping out of the slot in the head of the screw?*

164. *What advantages have the ratchet and the spiral screwdrivers?*

165. *How does a screw fasten two pieces together?*

166. *What should be the size of the hole in the outer piece—the one next the head of the screw—compared with the size of the screw?*

167. *With soft wood, when may a hole be needed in the inner piece also?*

168. *With hard wood, how large should the hole in the inner piece be compared with the size of the screw?*

169. *When is it unnecessary, usually, to countersink the heads?*

170. *What are the advantages of staggering screws?*

171. *Why should you stop turning a screw in soft wood when the head is driven to a bearing?*

172. *Why is it a bad plan to drive screws with a hammer?*

173. *Why do not screws hold strongly in end-grain?*

174. *Compare the advantages and disadvantages of nails and screws.*

175. *If driving a screw in hard wood is difficult, what can you do?*

176. *How can you increase the holding power of a screw in end wood?*

177. *When screws must be replaced in a worn hole, what can you do?*

178. *Is it stronger to screw through soft wood into hard wood, or* vice versa?

179. *How can you tell the sizes of screws?*

180. *When should you use lag screws? When should washers be used with them?*

181. *When you wish more strength than can be given with screws, what can you use? When should you use washers?*

182. *What objection, in outdoor work, is there to screwing bolts so tightly as to make depressions in the wood?*

183. *Name some kinds of screws in common use.*

184. *When should you use an expansive bolt?*

CLAMPS, HANDSCREWS, ETC. 185. *When should you use cabinet clamps? Show how to use them for a glued joint.*

186. *Show how to readjust clamps to correct errors in assembling.*

187. *Show some common substitutes for the regular clamps.*

188. *When should you use handscrews? Show how to adjust them.*

189. *When should you use carriage clamps or other metal clamps?*

190. *Explain the use of the wedge, and when to use a double wedge.*

JIGS. 191. *What are jigs? When is it worth while to make them?*

SHARPENING. 192. *What are the two chief operations in sharpening edged tools?*

193. *Compare the grindstone and the modern grinding wheel.*

194. *What is a hollow-ground basil? What are its advantages? When is it not desirable?*

195. *Show the process of grinding a chisel, plane-iron, spokeshave, etc., on a modern grinding wheel—on a grindstone.*

196. *How can you prevent injuring the temper of the tool?*

197. *How can you determine the proper angle at which to grind the tool?*

198. *How can you determine when you have ground enough?*

199. *Compare the old-fashioned oilstone made of natural stone with that made of modern abrasives.*

200. *Show how to whet a chisel, plane-iron, spokeshave, etc., on an oilstone.*

201. *How can you remove the wire edge? What is essential to bear in mind when removing it?*

202. *How can you know when to stop whetting?*

203. *How can you test the keenness of the edge? Which requires a keener edge, soft or hard wood?*

204. *Describe a strop. When should you use it? Show how to use it.*

205. *When the edge of a tool becomes slightly dull what should you do?*

206. *How do you know when to re-grind the basil?*

207. *Show how to sharpen a knife.*

208. *Show how to sharpen a common (outside) gouge. What is important in case of the gouge?*

209. *Show the use of the slip stone, and how to sharpen the inside gouge.*

210. *How should the curve of the slip stone compare with that of the gouge?*

211. *Show how to whet the drawknife.*

212. *Why must the scoring nibs of the auger bit be sharpened from the inside only?*

213. *Show the process of sharpening the scraper.*

214. *Show the process of saw-filing, for both cross-cut and rip saws.*

215. *What are the four main operations in sharpening a saw?*

SOME FUNDAMENTAL PRINCIPLES

The most important thing for the beginner is to have *sharp* tools of the best quality, and *clear*, *thoroughly-seasoned* wood of a kind suitable for the work.

THE PROCESS

271. How to go to work. What do you wish to make,—a sled, bookcase, doll's bed, step-ladder, poultry-house, boat? Do you know how to make it? What is the first thing to do? What comes next? What is the general process?

A Working-drawing or Plan. This is the starting point, as a rule. It shows the shape and dimensions of the whole object, and of each part, and how the parts are put together. A blue-print is often used.

Bill of Materials. Often attached to published drawings. From the working-drawings make a list of the number of pieces of each kind and their dimensions, including items of hardware and other materials. From these data the cost can be estimated.

Selecting the Stock. For all nice work use clear, well-seasoned stock of a suitable kind.

Laying out the Work. Mark the shape of each part accurately on the wood, ready to be cut. Sometimes all of this can be done at first, but in many cases a good deal of the laying out is done as the work goes on.

Getting out the parts. With saws or other tools cut them as marked. For nice work they are usually got out a little too large, to allow for dressing and smoothing to the exact size.

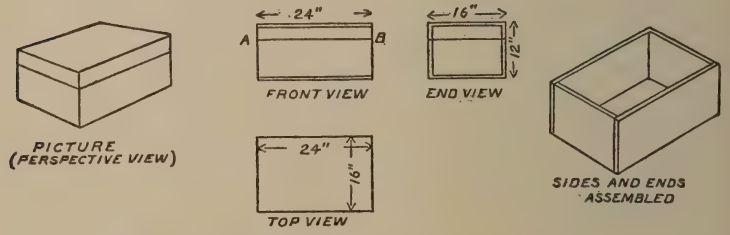
Dressing and fitting the parts. With planes or other tools

fit the pieces to the exact dimensions given on the working-drawing, and smooth them. Also, lay out and cut any special joints, openings, etc. Test all parts and see that they fit together accurately.

Assembling. Put the parts together permanently with nails, screws, glue, or in whatever way may be required.

Finishing. Repair any defects on the surface and see that it is clean. Then give the necessary coats of stain, filler, shellac, varnish, wax, paint, or other finishing materials. Frequently some or all of the parts can be finished better before permanently assembling, but this depends upon the construction of the object.

With machinery the general process is the same, but much time and labour are saved. In most cases, the parts can be got out, planed, fitted, and smoothed by machine. Much of the laying out is done by the adjustments of the machines. Finishing is also done by spraying machines and rubbing machines, as well as by dipping.



272. Illustration of Process. *Making a common box.* Suppose you wish it to be twenty-four inches long, twelve inches high, and sixteen inches wide. Take the exact dimensions as marked on the working-drawing (**273**), and make a Bill of Materials or Stock Bill (**278**). If it is to be a good box, select clear, well-seasoned stock, straight and not curled or twisted (**730**, etc.).

To make by hand only. Select the better edge of the board you are to use, mark the lengths of the pieces, using square

(**22**, etc.), and allowing a little extra length for each piece. Dress the pieces for the sides and ends to the finished dimensions, using square, plane (**132**, etc.), saw (**99**, etc.). After the pieces are of the right dimensions, and square and smooth, nail sides to ends (**202**, etc.), as shown above, and set the nails (**219**). Next, dress bottom piece almost to finished dimensions, leaving it a trifle large to allow for trimming after being nailed in place. Nail bottom to sides and ends, adjusting the sides and ends to fit the bottom, and testing with square. As the angles of the bottom are square, this will make the angles of the box square. Dress, fit, and nail top in the same way. Gauge line AB around box where it is to open (**28**, etc.). Saw in two by this line. Smooth these sawed edges. Fit hinges (**442**), and lock (**562**). Remove hinges and lock, see that the whole surface of box is smooth, and repair any defects (**394**). Finally finish (**394**, etc.), and permanently replace hinges and lock.

To make with machinery. Cut the pieces a little too long with the swing-saw (**626**), or on the circular saw bench (**585**, etc.). Joint (plane) one edge of each piece with jointer (**654**). Saw to width (allowing a trifle) with circular saw. Joint the edge just sawed. Cut one end of each piece square on circular saw bench, then the other end at the required distance. Make one broad surface of each piece flat or true on the jointer. Then run through surfacer (**646**) to plane the other side, or over jointer. Sand each piece with sander (**664**). Assemble by hand. The outside can be sanded after assembling. Saw box in two with circular saw. Joint the sawed edges if necessary. Fit hinges and lock. Remove hinges and lock, and finish by spraying with spraying machine; or finish by hand.

Common sense must be used. Some things are so simple that you can carry the whole plan in your mind without any drawing at all, and when you copy an object you may need no plan. Also, with such work as a chicken-coop, some of the processes given above may be omitted; but, as a rule,

for all good and important work, from a footstool to a sail-boat or a house, there is nothing gained by skipping any of the operations practiced by skilled workmen. You will soon find however that these operations sometimes overlap or come in slightly different order. You may have to do some sawing, planing, etc., before you can do all the laying out, some assembling before all the parts are fitted, some finishing before assembling. **Summary.** With a working-drawing as a guide, select the stock, lay out the work, get out the parts, fit and smooth them, assemble, and finish.

273. A Working-drawing, unlike a picture, gives the exact shape and size of an object, and of each part of it, and shows how the parts are put together. It is drawn to scale, that is, either the full size of the object or in the same proportion. In plans for a house, for example, ¼″ or ½″ may represent 1′ of the actual house.[1] The symbol ″ means inches and ′ means feet.

If you can make working-drawings, you can carry out your own ideas satisfactorily. The appearance of the object, its strength, the proper materials, how they are to be put together, and all matters relating to the construction, have to be considered in making a working-drawing or in selecting one already made. What you would see if you were looking down on the object from directly above is called the *top view* or *plan.* What you would see if in front is the *front view* or *front elevation;* if opposite the side, the *side view* or *side elevation.*[2] If the other side or the rear are different, there will be another *side view* or a *rear view.* Details within an object, or parts you cannot see, are often shown by dotted lines (**523**). Sometimes a "section"[3] drawing is made to show what would be seen if

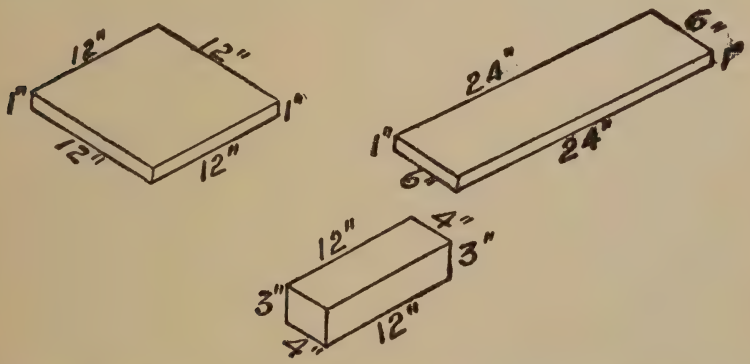
[1] Such a drawing is on a *scale* of ¼″ = 1′ or ½″ = 1′. If 6″ = 1′, the drawing is called half-sized. If 3″ = 1′, it is quarter-sized.

[2] This is merely a rough explanation. The top, front, or side views are, strictly speaking, the way each would appear if you could look at it from an infinite distance.

[3] Latin, *sectio,* from *secare,* to cut.

the object, or some part of it, were cut through (483, 494). With complicated objects separate drawings of the details are made. Sometimes, for a simple object, a plan and one elevation are enough. Sometimes many views, sections, and detail drawings are needed. Dimensions are shown between arrows, and various kinds of lines are used for different purposes. Use the dimensions stated instead of measuring the drawing, for the dimensions are more likely to be accurate.[1] References: *Problems in Mechanical Drawing*, BENNETT. *Mechanical Drawing*, ERMELING, FISCHER, and GREENE. *Mechanical Drawing*, FRENCH and SVENSON.

274. **A Blue print** is a copy of a working-drawing, made by placing sensitized paper behind a tracing of the drawing, and exposing to light in a photographic printing-frame. After sufficient exposure the sensitized paper is washed and the black lines of the drawing become white lines on the blue print.



275. **The unit of lumber measurement** is represented by a board one foot square and one inch thick.[2] This contains

[1] In factories, for some kinds of cabinet work, a full-sized drawing is made accurately on a board. This is called a *rod*, and the workman uses it as a guide.

[2] A board 1″ thick, 12″ wide, and 12′ long contains 12 feet, board measure. A board 1″ thick, 6″ wide, and 12′ long contains 6 board feet.

144 cubic inches, and any piece containing 144 cubic inches, as shown above, is a board foot. Most lumber is sold by the board foot, the price being set by the M (1,000 feet). Thus, if pine boards are selling at $100 an M, one foot will cost ten cents. Lumber comes in the rough (not planed) or planed. If planed on one side, the symbol S1S (surfaced one side) is used. If planed on two sides, S2S.

276. **To find the number of feet** in a piece of lumber multiply the thickness (inches) by the width (inches) by the length (feet) and divide by 12.[1]

277. **To estimate the cost,** multiply the number of board feet by the price for one foot or for one M. Make liberal allowance for waste. This varies with every job. Add to the estimate for lumber any items of hardware, paint, varnish, etc.

278. **Bill of Materials.** This should include whatever items are required for the work in hand. Set down the most important parts first, giving thickness, width and length of each in the order named,—length always being with the grain (292). For example:

Name of Piece	No. of Pieces	Remarks	Thick-ness	Width	Length	Plan-ing	Board feet	Price a Foot	Cost	Hard-ware, etc.	Cost	Total Cost

For use in the shop you can easily make out a simple *Stock Bill* giving any details required.[1] For example:

Thus to measure twelve-foot stock simply find the width in inches. If the board tapers, measure at the middle. In case of a plank (more than one inch thick), multiply the width in inches by the thickness of the plank. One 3″ thick, 7″ wide and 12′ long contains 21 board feet. This method is easily applied to lumber when the length or width is a convenient multiple or divisor of 12. Stock thinner than 1″ is usually measured as if 1″ thick. Tables are published for quickly obtaining lumber measurements. Lumber is graded and priced according to quality.

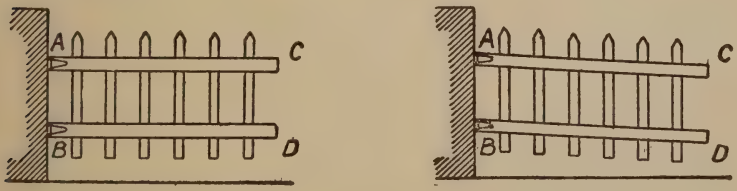
[1] In manufacturing shops length may come first, width next, and thickness last.

Name of Piece	No. of Pieces	Remarks	Finished Thickness	Finished Width	Finished Length

A FEW ELEMENTARY PRINCIPLES OF CONSTRUCTION, OFTEN VIOLATED

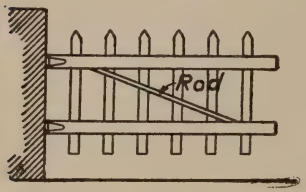
279. Importance of diagonal members. Make a triangle with three strips. Push or pull it sideways and it will hold its shape, unless enough force be applied to break it. Make

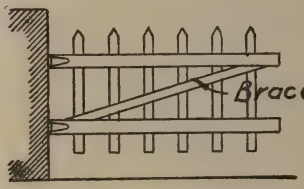
a rectangle with four strips. A little pushing or pulling sideways will alter the shape. Add a diagonal, making two triangles. Now pushing or pulling sideways will not alter the shape, unless you apply a breaking force. This principle is applied to innumerable structures, to prevent change of shape or destruction.



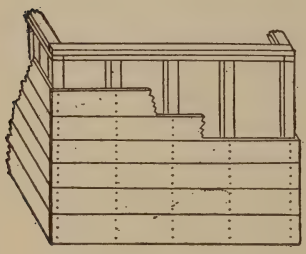
280. A gate is often built as shown, for example. At first the diagonal measurements AD and BC are equal. Such a

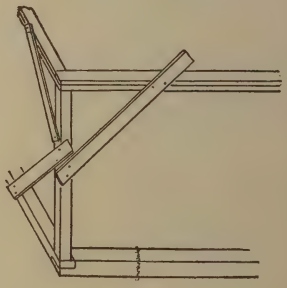
gate soon sags, however, even from its own weight alone. The distance AD becomes longer and BC shorter than at first, as A and D are pushed farther apart while B and C are drawn nearer together.





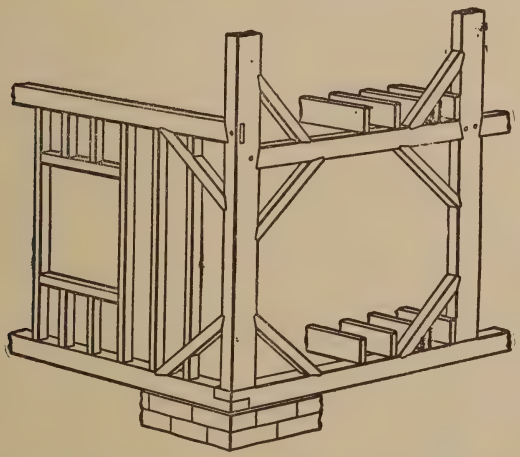
281. Tie A and D together with a diagonal rod and the gate will keep its shape, except for a slight sagging as the joints settle to a bearing, curable by tightening the rod. A rod is stronger for a pulling strain than a strip of wood. Or, a wooden brace or strut will prevent B and C from being drawn nearer together. A brace stands a pushing strain better than a rod, which would bend. Sagging gates, cleated doors, etc., often require a diagonal brace one way or a tie the other. For rough work a wire twisted can sometimes be used (237).



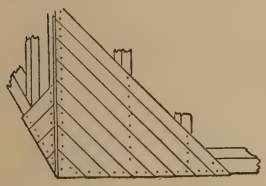


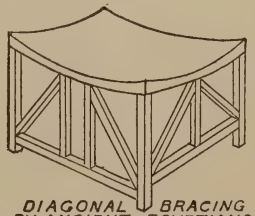
282. Diagonal members are often omitted in the framework of light buildings, where the boarding is fastened to so many parts of the frame with so many nails as to give a stiffening effect more or less like that from diagonal bracing.

In such cases temporary diagonal boards, or "laths," are usually nailed on to keep the frame in shape while boarding.



283. Diagonal corner braces are used for a large, important structure, so that the frame will hold its shape without being dependent upon the boarding or nailing.

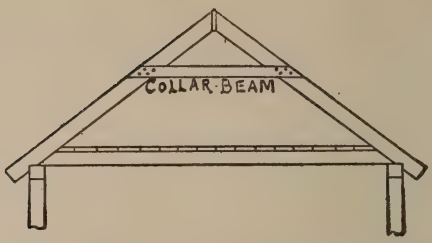




DIAGONAL BRACING BY ANCIENT EGYPTIANS

284. Diagonal boarding is usually considered better than horizontal or vertical in buildings of the better class, but the frame also should be braced diagonally, or shrinkage of the diagonal boarding may force the frame out of shape. See also *Crate-making* (342, 343).

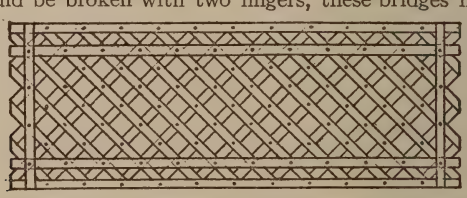
285. In case of a roof made as shown, the collar-beam (and also the floor timber below), by completing a triangle, holds the rafters in place and prevents the pushing out of the sides of the building. From such examples we see that all



rectangular structures subject to strain should be diagonally braced or tied.[1]

286. Cross-strain, Tension, Compression, and other strains.[2] Lay a twig across two supports. Hang a weight in

[1] An old-fashioned wooden lattice bridge illustrates these principles. Pupils of the writer have made little bridges of this type, 6′ or 8′ long, and 14″ high, with strips of soft pine $^1/_8$″ thick x $^1/_2$″ wide. While any strip could be broken with two fingers, these bridges held thousands

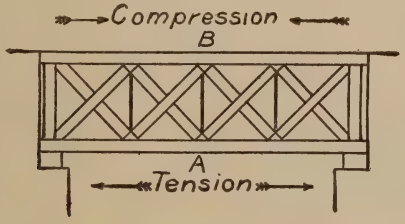


of pounds and required a system of long levers to break them. This shows the strength derived from combination of individually weak members arranged diagonally; and also that a model is much stronger proportionately than a large structure. This is not a scientific construction for a modern bridge, though when lumber was very abundant many such bridges were built, and some are still standing.

[2] A piece of wood may be strained or destroyed in several ways: by being stretched or pulled apart,—*tension;* it may be crushed or pushed together,—*compression;* it may be broken across,—*transverse, or cross-strain;* it may be twisted apart by *torsion;* or cut across by *shearing.* It may be broken or injured by any or several of these strains.

the middle. As the twig bends, the bark will pucker on the upper side, showing that the top is being shortened or *compressed*. The bark will be stretched, and perhaps cracked, on the under side, showing that the lower part is being lengthened or pulled out (subjected to *tension*).

287. **When a beam is used** for a floor-timber in a building, or for a bridge, it will have the same cross-strain on it as the twig (286), shortening (compression) in the upper part and pulling (tension) in the lower part.

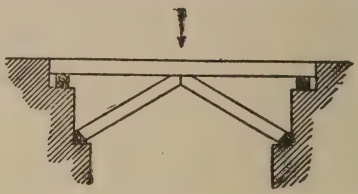


288. **This applies not merely** to one timber or stick, but to structures built up of many pieces, like the trusses (sides)

The strength of a piece of wood or metal to resist crushing, tension, or shearing is in proportion to the area of its section. A piece with a section two square inches in area is twice as strong as one with a section one square inch in area. The strength to resist a transverse or cross-strain is *as the width, inversely as the length,* and *as the square of the depth.* Doubling the width doubles the strength. Doubling the length divides the strength by two. Doubling the depth multiplies the strength by four. That is, a beam four inches wide will support twice as much weight as one two inches wide. A beam ten feet long will support twice as much weight as one twenty feet long. A beam eight inches deep will support four times as much weight as one four inches deep.

In making splices and other joints where strength is required, it should be borne in mind that the strength of any structure is limited by the strength of its weakest part, therefore the aim should be to make a joint or splice as nearly equal in strength to the parts it connects as possible. The joint best for one strain is usually not the best for another, therefore the fewer different strains a joint is subjected to the better. A plain butt joint fastened to prevent movement sideways is sufficient for compression, but often requires strengthening for cross-strain also. Joints to be subjected to tension require careful planning to preserve so far as possible the full strength.

of a bridge, or of a roof. The whole structure is always under cross-strain. If there is no load on it, it is under cross-strain from its own weight, and, like the twig, the upper part is under compression, the lower part under tension.[1]



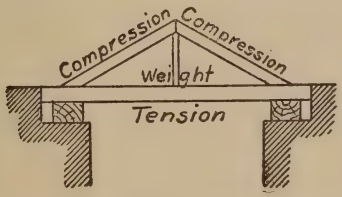
289. The simplest way to bridge over a short distance is to lay a beam on edge. For a wider distance the beam (or girder) can be supported by braces as shown. The weight on the beam, bearing downward, will push or thrust on the braces and they will be under compression, one-half the thrust being put upon each brace, which in turn pushes against the abutment.

290. The braces can be put on top, and the middle of the beam hung from their apex. When the beam begins to bend

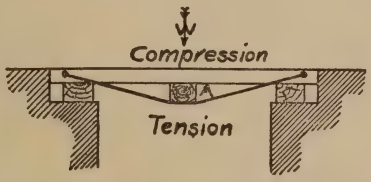
[1] To destroy a wooden railroad bridge, saw through the lower chords, as they are called (A), and the bridge will fall, for the lower part is under the strain of tension and trying to pull apart all the time. If you saw the upper chord (B) instead, the bridge will still stand, for the top is under compression and the saw-kerf will immediately close up like any butt joint that is being pushed together. In fact the pressure will bind the saw unless the kerf is forced open. The bridge will not be so strong, since an unsecured butt-joint might work out of place, but it will not fall unless the sawed chord be moved.

A beam will bear twice as much weight equally distributed over its length as when applied at the centre. In such structures a good deal of the material is arranged at the top and bottom to resist the compression and tension to the best advantage, as in the truss just shown, or in a common I beam of iron.

with the weight applied, it pulls on the rod at the middle. This rod, hanging from the apex, pushes the braces, and the



braces, being fastened to the beam, in turn put the beam under tension.

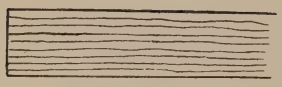


291. A beam is often strengthened or stiffened as shown. The weight at W bending the beam, pushes the strut or block A, and this pulls on the rod, which applies compression to the beam.

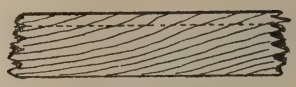
These illustrations show the general principles which, often carried much farther, apply to the construction of many comparatively simple pieces of work, as well as complicated roofs, bridges, and the like.

PARING AND FINISHING TO SHAPE

292. Grain. Piece of wood magnified, showing fibres running lengthways.

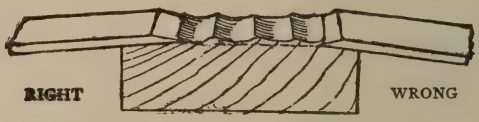


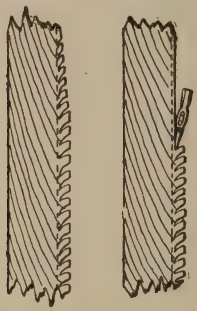
STRAIGHT GRAIN

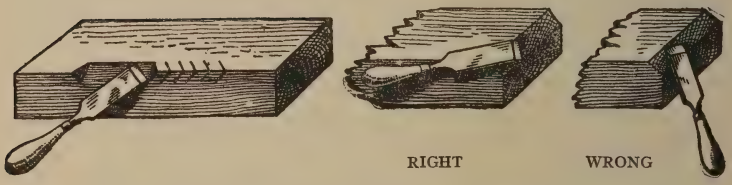


CROOKED GRAIN

These show as lines on the surface, and are called the "grain." While you can generally tell by these markings on the surface, you can not always rely on them, for the direction of the grain is often complex and not readily detected.







293. **Trimming to a line.** Whether using hatchet, chisel, drawknife, knife, or other tool, *cut with the grain* if possible. You can often score the waste wood with cuts nearly to the line. This breaks up the grain of the wood and, with crooked-grained stock, makes the paring easier. Then trim carefully, with the grain if possible, to the line with hatchet, chisel,

draw-knife, or other tool. See **159.** Use a shearing cut when you can (**77**). See *Chisel* (**83,** etc.).

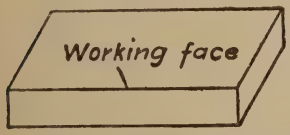
294. When you cannot saw a curve, make saw-kerfs nearly to the line. Remove the waste wood with chisel, draw-knife, or other tool, cutting *with the grain.* Then trim to the line. Cutting against the grain is harder, and usually leaves the surface rough, or splits off what you wish to keep. See also *Plane* (**132**, etc.), and *Chisel* (**83**, etc.).

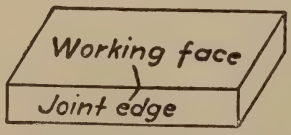
295. To shape objects like hammer or axe handles, paddles, spoons, curved table-legs, etc., first cut to the outline on two opposite sides and then to the outline on the other sides. See **637.** Then the rounding or modelling can be done with shave, gouge, chisel, rasp, file, etc. Such work, as well as the simpler forms of shaping, is now usually done with machinery, special machinery often being used.

SQUARING STOCK TO DIMENSIONS

296. Squaring to dimensions may involve measuring and marking (**13**), squaring (**22**), gauging (**28**), sawing (**99**), and planing (**132**).

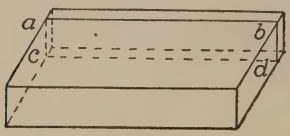
First get out the piece a little larger than the required or final dimensions; perhaps $^1/_8''$ thicker, $^1/_4''$ wider, and $^1/_2''$ longer. If it be curled, warped or winding, allow more thickness than if the surface be flat.

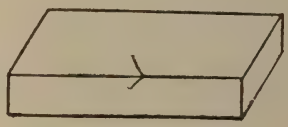




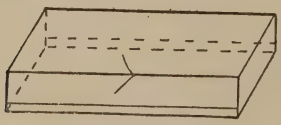
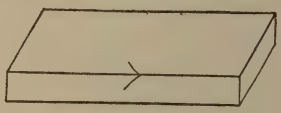
297. Working-face or Face-side. See **27, 72.** Select the better side. Plane it flat. Call it the *working-face* or *face-side,*

and mark it at the edge as shown, or in any way to distinguish it. **Joint-edge.** Select the better edge. Plane it straight, and also square with the working-face. Call it the joint-edge or working-edge, and mark it as shown, or in any way to distinguish it.

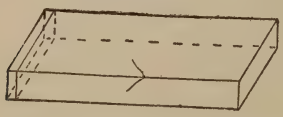
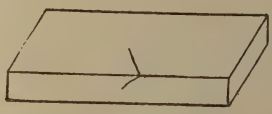




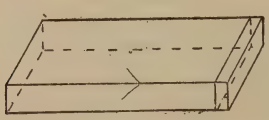
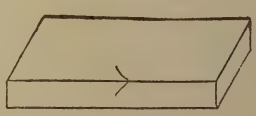
298. **Mark required width** with the gauge on both sides, gauging from the joint-edge already made, as shown by lines *ab* and *cd*. Cut away the wood to the gauge lines just marked.

299. **Mark thickness on both edges** with the gauge, gauging from the working-face or face-side, already made flat. Plane to the gauge lines just made.

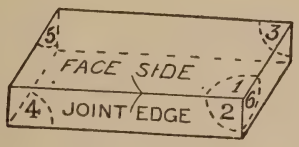



300. **Mark one end square,** unless it be so already. Saw or plane (or both saw and plane) the end just marked, until it is square, using the block-plane or smoothing plane if you have one.

301. **Measure and mark the required length** from the end just squared, using rule and square. Saw or plane (or saw and

plane) to the lines just marked. If you have done the work accurately, the piece is now "squared up," or squared to dimensions.[1]



302. Summary.

True side 1.

True edge 2, square with 1.

True edge 3, parallel with 2, and at the required distance from it.

True side 4, parallel with 1 and at the required distance from it.

True end 5, square with 1 and 2.

True end 6, square with 1 and 2 and at the required distance from end 5.

[1] The squaring-up process is one of the fundamental operations of woodworking, but stock is now trued and squared so much more quickly, easily, and better by machinery than by hand that going through the whole operation by hand is not necessary for ordinary work. Parts of the process are often required, because of lack of available machinery, and there are occasional cases in which the whole operation must be done by hand. Therefore the beginner should be able to do it, for the principle on which it is based has many applications in both hand and machine work. There are other processes than the one given above, but the distinctions are not important for the beginner.

Theoretically, if the working-face, joint-edge, and one end are made true and square with one another, planing to the marks on the opposite side, edge, and end is all that is necessary, without testing to see that the surface is straight and true. But, practically, no part of the work will be perfect; therefore if dimensions are more important than accuracy of shape, there is no object in testing after the work has been cut to the lines, for any alteration would change the dimensions. On the contrary, if accuracy of shape is more important than exact dimensions, the surfaces and angles should be tested and corrected, even though this makes a slight change in the dimensions.

QUESTIONS

1. *What does a working-drawing show?*
2. *What is a blue-print?*
3. *In what order is it customary to give the three dimensions of a piece of lumber?*
4. *What does S2S mean?*
5. *What is the unit of measurement for lumber?*
6. *What is a board foot?*
7. *How do you find the number of board feet in a piece of lumber?*
8. *What is a plank?*
9. *How do you find the width of a tapering board?*
10. *Show how to make out a Bill of Materials—a Stock Bill for shop use.*
11. *Show the importance of diagonal members. Give illustrations.*
12. *What is the object of a collar beam in a roof? To what stress is it subjected?*
13. *Define tension, compression, cross-strain, torsion, and show how these stresses are developed in large and small structures.*
14. *How do the dimensions of a piece of timber affect its strength when under cross strain?*
15. *What is the most important thing when paring or trimming to line?*
16. *Show simple ways to remove waste wood.*
17. *In shaping odd-shaped forms, like a wooden spoon, a paddle, a model boat, what is the process?*
18. *Show the process of squaring a piece of stock to given dimensions by hand.*

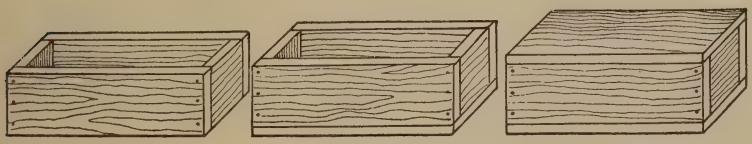
SOME COMMON OPERATIONS

ASSEMBLING

303. Assembling. How to put work together depends on what you are making. Look over all the parts to see that they are ready to put together. Before using glue, see that the parts fit.

Each type of construction has its own problems. Therefore study the working-drawings to see which are the most important parts. Assemble these first, as a rule. You cannot assume, because all the different parts are of the right size and shape, that the whole object will have the right shape when the parts are put together.

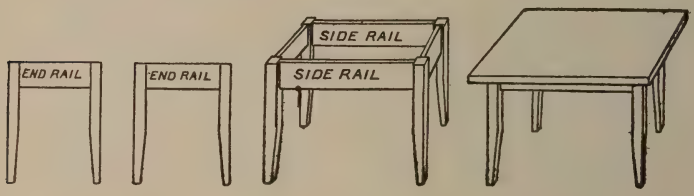
While assembling, keep testing by eye and with testing tools, particularly while putting the main structural parts together, for mistakes in the general shape are worse than in the details. Small work can usually be tested accurately by eye, with squares, etc. Have horses for assembling. They can be padded for nice work.



304. Typical examples: A common box. Nail sides to ends. Then nail bottom, fitting sides and ends to it. If the parts have all been cut accurately, this will make the angles of

the box correct. Test however with square, as you nail. Add the top.

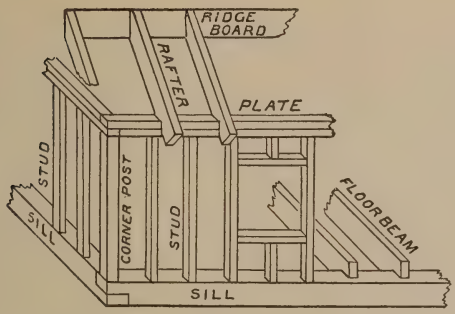
305. A common four-legged table or stool. Assemble two end legs and the rail which connects them. Also, the two



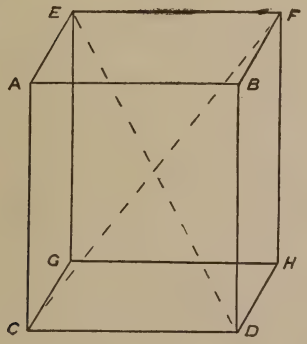
opposite legs and rail. After these are dry, join with the two connecting rails. Then add the top. In general, the ends of tables, sideboards, settles, bureaus, bookcases, and the like are assembled first; then the lengthways or connecting parts, rails, shelves, seats, etc., finally adding the top, if there be one. Do not use glue in attaching table tops, the tops of large seats, or similar broad surfaces (**747**). Panels must not be glued in place (**376**).

306. A mitred picture frame. Put one corner together. Also the opposite corner. When these are dry, fasten the remaining corners. See **508.**

307. Frame of a one-storied building. Put the sills in place, then the corner-posts, the studding, the plates. The floor beams and first floor are often laid at first, for convenience. Boarding of the sides is usually done as soon as possible. Then the rafters, ridgepole, if there be one, collar beams, and the boarding of the roof. Then door and window frames,



corner boards, clapboarding or shingling, and various other details.



308. Case work. Suppose ABCDEFGH represents the outline or general shape of a bookcase, cabinet, wardrobe, bureau, or other large rectangular object. Before assembling the whole, test the side ACEG until it is rectangular and flat. Do the same with the opposite side BDFH, the top ABEF, and the bottom CDGH. When you put these parts together, besides using the eye and the square, measure the diagonals of the front, AD and BC, with an extension rule or with two sticks (**17**). If not equal, make them so by hand, or with clamps, or by inserting a temporary brace. Do the same with the diagonals EH and FG at the back. Still, the front edges

ABCD and the back edges EFGH may be out of line (winding); therefore measure the remaining diagonals AH and BG, ED and FC, and correct any error in the same way. Of course all bracing sticks must be left in place, like the clamps, until the glue is hard. Two persons can do such work better than one.

309. **Test the sills of a building** with the level and test the diagonals from corner to corner with the steel tape or with sticks. Plumb the corner posts.

310. **For work spaced at regular intervals,** like lattice work, fence pickets, etc., take a piece of wood of the same width as the space between the pieces, and hold it beside each piece to measure the distance at which to nail the next one.

311. **Nails, screws, glue,** bolts, strap-irons, corner-irons, draw-dogs, and many other fasteners are used in different kinds of assembling. See 450. Hardware fittings, hinges, locks, escutcheons, etc., are fitted before the finishing process. For nice work these fittings are then removed and put on again after the finishing. Paint the joints of unprotected outdoor work, like swing-frames, wagon-bodies, etc., with lead paint before assembling; and do not force bolt heads into the wood, as the depressions retain water and hasten decay.

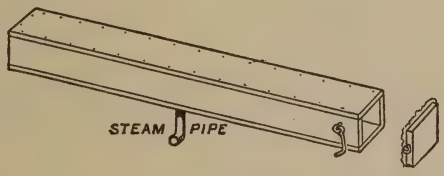
Summary. Study the construction. Put main parts together first. For cabinet work and the like, first rehearse the process. Have parts marked, clamps and glue at hand. Keep testing. Test diagonally.

BENDING WOOD

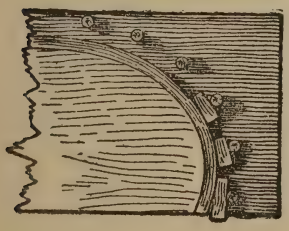
312. **Bending wood.** Essentials: moisture and heat. Some woods, like oak, bend better than others, for their fibres are better able to adjust themselves to a change of shape. Use straight-grained stock. Dry stock needs moisture. Steam it in a steam-chest,—a wooden or metal box connected with a steam-pipe. Bend at once after steaming. If you cannot do

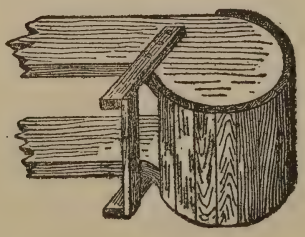
that, soak in boiling water or even cold water; or pour boiling water over pieces wrapped in cloth or buried in sawdust or sand, well covered, and leave to soak in the steam. Long boiling weakens the wood, as does very great heat. Steamed wood stays bent well, but boiled wood often straightens more or less after it is dry, so bend it too much, unless it is to be fastened.

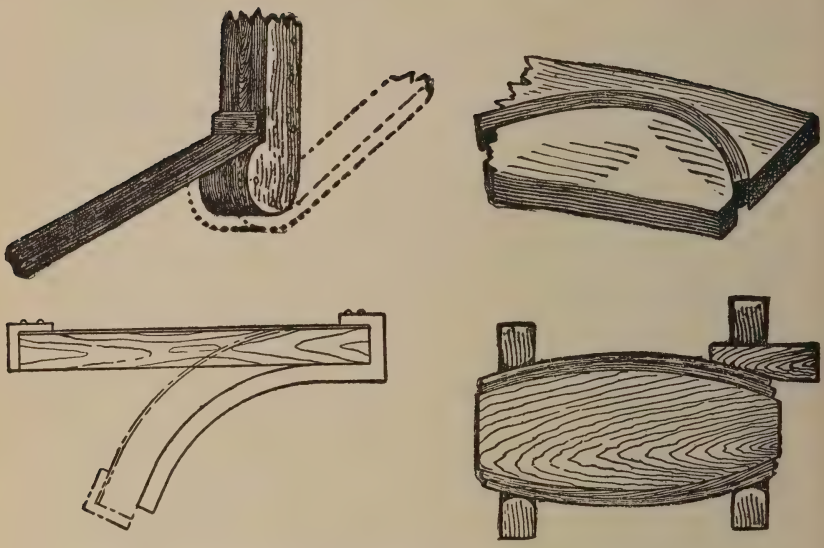
Slender pieces of dry wood can be bent by soaking in hot water and then applying a high degree of heat. Contrive a "form" for bending. Try to fit some kind of a strap (sheet metal or even a thin strip of wood) to prevent splintering on the outside of a sharp bend. Some pieces can be bound to the form with canvas or adhesive tape. Keep bent until thoroughly dry. Bending is often done by end pressure, with a strap outside.



313. Steam-chest of wood, easily made. The pipe shown can be connected with any steam pipe, or even with a tightly covered kettle. One end of the box is tight. The stock to be steamed is inserted through the open end, which is then stuffed with burlap or rags, or can have a hinged door.





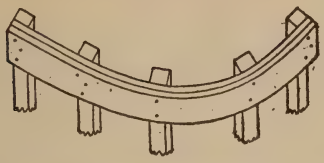


314. **Suggestions for forms for bending.**

315. **Where only one side will show,** and strength is not important, make saw-kerfs across the back side. After bend-

ing, wedges can be fitted and glued in the kerfs, if they are on the convex side, to increase the strength.

316. **Where appearance is not important,** two or more thin strips can sometimes be used, or a piece can be split and then bent. Thin pieces can be glued together after bending by using forms or cauls. To bend a moulding it sometimes can be sawed



into strips lengthways, preferably where the sawing will show the least, then bent and nailed, or glued in place.

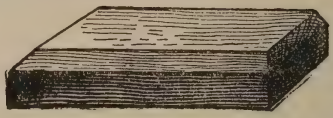
317. Bent wood is strongest and least likely to splinter when bent at right angles to the medullary rays (**731**) and in the direction of the annual rings (**731**), as at A; but is more easily split by nails than if bent in the direction of the medullary rays, as at B.

BEVELING AND CHAMFERING

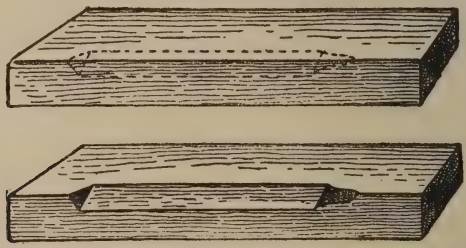
318. Beveling and Chamfering. A bevel extends across the whole edge or surface. A chamfer does not, but makes an

additional surface,—cuts away the angle formed by two surfaces. For nice work mark with a pencil, for the gauge may deface the work. Plane to the line, or pare with chisel or other tool, with the grain if possible. When chamfering or beveling an edge with the wood in the vise hold the fingers of the left hand against the wood to steady the plane (**141**). Guides to attach to the plane, for planing at any angle, with the wood in the vise, can be bought. Test chamfers and bevels by eye and with the bevel (**34**), etc. Chamfering and beveling are best done with the Jointer (**654**), the Circular saw (**585**), the Sander (**664**).

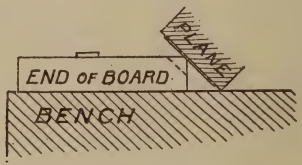
319. **Chamfer laid out and cut.**



320. **If the end also is to be chamfered,** do it first, with a shearing cut (153). Some cut the end last.



321. **Stop-chamfer.** When the plane cannot be used, pare with the chisel. Trim the ends carefully or cuts will be left to deface the work.

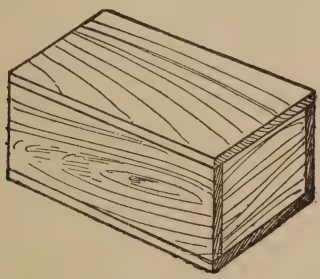


322. **A chamfer at the edge of a board** can be cut with the board flat on the bench, tipping the plane and sliding it along with the edge of the sole resting on the bench.

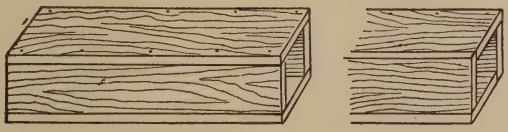
BOX-MAKING

323. **Box-making** requires accuracy,—making every piece rectangular, every edge square. Best done by machine.

324. A common type. Nail sides to ends. **Put bottom in** place. Adjust sides and ends to bottom, and nail. Test with square when nailing. Then add top. In boxes like this, have

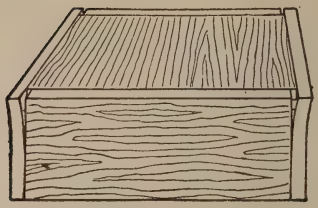


the grain of the sides and ends run in the same direction—around the box, as shown. Nails fasten the sides to the ends fully as strongly as screws, because screws do not hold well in end-grain. Glue has not much value with end butt joints, usually. Screws hold the top and bottom more strongly than nails, because they are driven into side-grain. Glue should not be used for the top and bottom, except for very small boxes.

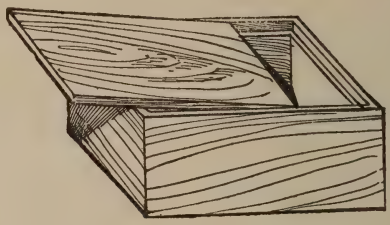


325. For a box like this have the grain run the other way (lengthways). For the four long joints, screws and glue can be used if you wish, because these joints are all side-grain, and the grain runs in the same direction in all the pieces. Therefore, expansion or contraction of the width of the pieces will not affect the joint. The four pieces can all be of the same width, and can lap as in the second illustration, if you wish.

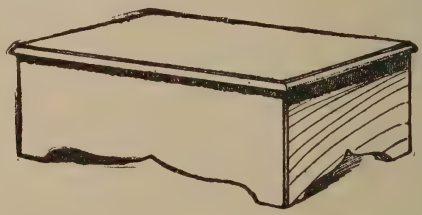
326. Result of fitting the bottom tightly between the sides. Swelling of the bottom has forced the joints open. Shrinking



would have left a crack. Fitting a bottom in this way is only suitable for quite small boxes, because swelling and shrinking of wood cannot be prevented (747).

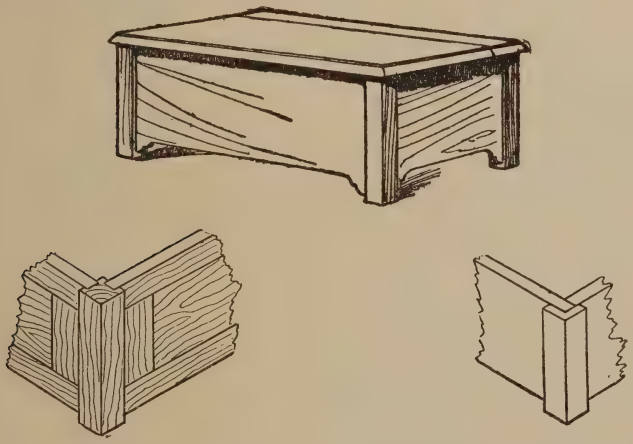


327. Another box shown bottom up. For nice work fit bottom loosely into a rabbet (567) cut in the lower edge of the sides and ends, or into a groove cut just above the bottom, as in a drawer (387).

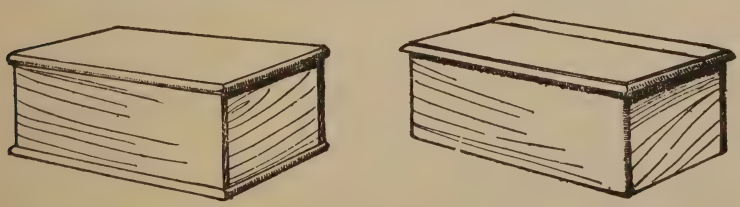


328. A rabbeted joint is good for a box, is neat and inconspicuous. The corner can be nailed both ways and can be rounded. In a case like that shown, the bottom can be fitted in a groove on the inside. Glue can be used also, because of the shoulder. Dovetailing (519, 520) is the most workmanlike way to fit box corners for the best work, but requires much

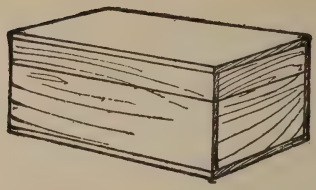
skill and is now done by hand much less often than formerly. Mitred joints (**508**) are sometimes used but are seldom very strong, unless reinforced by splines or keys, or combined with a rabbet, dovetail, or other joint. Such joints require much skill to make by hand, but are suitable for very small boxes of valuable wood, and in other special cases. Corner blocks (**450**) glued, nailed, or screwed can sometimes be used for strengthening some parts of boxes.



329. Sides and ends grooved into corner-posts. Sometimes used for elaborate chests. Each side and end is often framed with a panel (**372**), and then set in grooves in the corner-posts. Sometimes a rabbeted post is used to cover the joint.

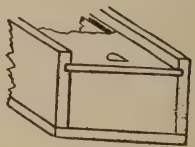


330. Other simple forms. When a box is to open below the top, fasten top in place, and then cut the box in two at

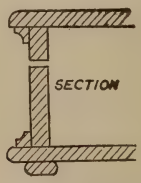


the desired place with a fine circular saw or by hand. Drive no nails near the line to be sawed. If necessary to saw by hand, gauge two parallel lines around the box, the width of a saw-kerf apart, and saw between them carefully. Saw from each corner in turn. Trim the edges with a long plane (**154**).

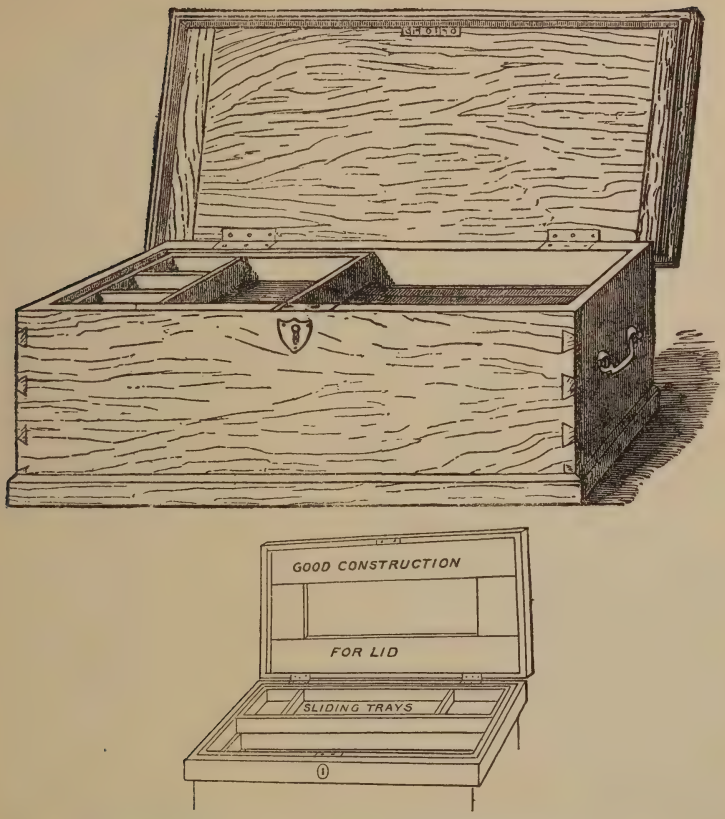
331. **Lids or covers,** except for rough boxes, should be strengthened and kept from warping by cleats at the ends, or on the under side (**365**), or by framing or paneling (**372**). If the top and bottom of a large box are boarded lengthways there will be fewer cracks, but less strength, than if boarded crossways.



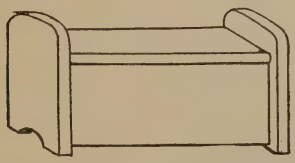
332. **Sliding lid for small boxes.** The lid must have some play sideways, as with panels (**376**). See *Grooving* (**441**). To prevent the grooves showing at the back end of the sides, stop them before reaching the end, and finish with a chisel.



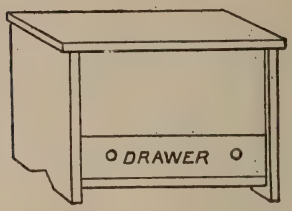
333. **Overhanging top and bottom** sometimes used for a chest to avoid paneling.



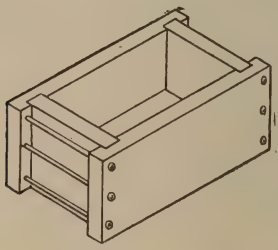
334. **Common form for chest.** Lid is framed and panelled. See **372.**



335. **Box construction used for seats.** Cushion can be added. Lid can be hinged.



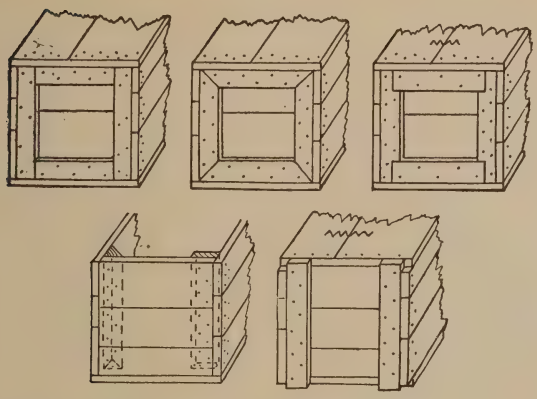
336. Box or chest with drawer.



337. Dado or grooved joint common for tanks, cisterns, etc. The liquid swells the wood and helps to make the joint tight. The bottom can be grooved into the sides and ends (**441**). For tanks, apply white lead freely in the joints. See **Dado, 463.**

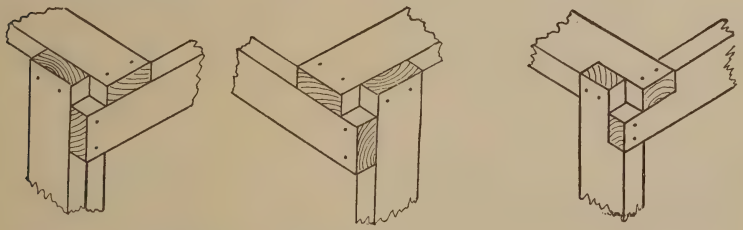
338. Simple form for feet. A great variety of feet are sometimes used, as claw feet, etc.

339. Packing boxes. Common packing boxes are often weak at the ends, to overcome which various styles of reinforcement are used. Corrugated fasteners (**202**) are often used to strengthen edge-joints. Using hardwood for the ends and cleats, into which the nails are driven, increases the strength of the box. Cement-coated nails hold more strongly than smooth ones; smooth ones better than barbed. See **208.** Metal straps also add much to the strength.

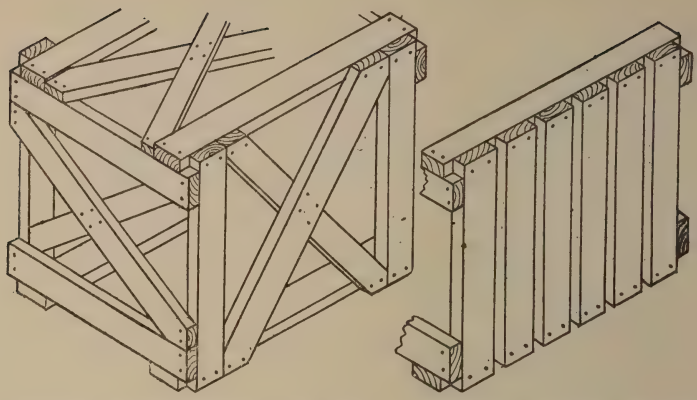


340. Re-inforcing ends of Packing boxes.

341. Packing crates. The weakness of crates, as often made, is largely due to lack of strength at the corners, to lack of diagonal bracing, and to insufficient nailing.



342. " Three-way " corner or lock-joint for packing-crate. The best way when the crate is shaped like a common box. A strong corner, because each piece is nailed in two directions, and the nails are all driven into side-grain. A nail driven into side-grain holds from one-third to one-half more than if driven into end-grain. This corner helps toward diagonal bracing, and also cannot come apart, or be taken apart, without drawing the nails or splitting the wood. If the crate has an odd shape and requires unusual bracing or crosspieces to keep the contents in place, some other form may sometimes be better.



STRONG CRATE—DIAGONAL BRACING THIS CRATE IS MUCH WEAKER

343. Experiments at the Forest Products Laboratory, and by others, have shown by tests how much stronger diagonally braced crates are than when the slats are all parallel with the edges. Less material is required also. The omission of a diagonal on even one of the six sides lessens the strength to a considerable degree.

CARVING

344. A Few Elementary Operations in Simple Carved Work. The true carver can not get his inspiration from a book, nor even from a master, but must have in him that artistic feeling, and power of execution, without which his work will not rise above the level of manual dexterity. No attempt can be made to teach the art of carving in a few pages, but it is well, however, to have some understanding of the methods by which the simpler forms are shaped, for the general woodworker often has occasion to work wood into odd shapes.

Elementary practise in carving can well precede the more mechanical forms of woodwork, for the training of hand and eye and mind given by it are of great value, not merely in the

way of general development, but as increasing one's ability to handle the more mechanical processes later.

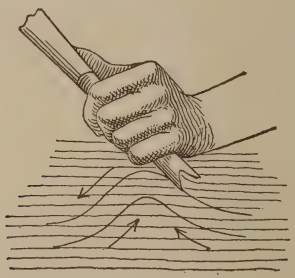
It is common to advocate beginning with soft wood, but there are some advantages in starting with good, clear-grained oak, not very hard. Pine, black walnut, mahogany, cherry, gum, and other woods can also be used, if straight-grained.

345. The simplest tools are similar to other chisels and gouges, but are sharpened on both sides, and are of a great variety of sizes and degrees of curvature. The edges must be ground and whetted to be *very keen*, and must be *kept so* by frequent stropping. They should not be used for other work.

A carver's bench is usually a little higher than a cabinet-maker's or a carpenter's, but a special bench is not necessary unless much carving is to be done, as it is easy to block up the work. The bench should face the light, which should come down on the work if possible. Carving should be done standing, for it is hard to get the proper freedom of movement while sitting. A variety of holdfasts and clamping devices to keep the work in place are in use, but simple work can usually be held by the vises, clamps, wedges, etc., used in ordinary woodwork.

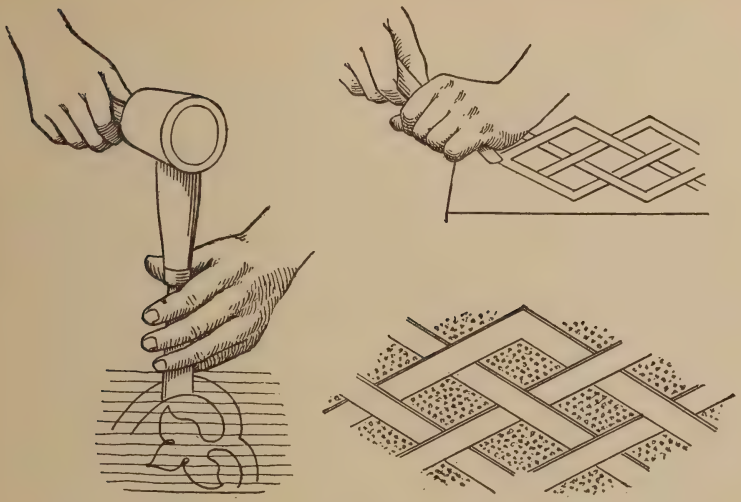
The variety of odd-shaped carving tools occasionally used by carvers is very great, but for the work of the beginner or the general woodworker only a few of the simplest kinds are needed. A couple of skew-chisels, half a dozen gouges, a V-tool, veining-tool, and a couple of straight chisels are enough to do a great deal of simple work. More can be added when needed. It is well to have the handles of carving tools of different pattern from those of the other tools. The outside of a carving gouge or parting tool is sharpened much the same as other tools, but the inside bevel is made by rubbing with a slip shaped to fit the tool (**262**). Lay the tools on bench before you but behind the work, with the handles away from you, as it is quicker to pick the tools up by the blades and to select the tool required.

346. Clamp the wood firmly, so that both hands can be free. Push with the hand which grasps the handle, check and control with the hand which governs the blade. (See Chisel, **83,** etc., **93**). When the pushing force of the hand is not sufficient, a slight blow can be given the tool handle with the hand, but it is usually better to use the mallet. The direction of the lines of the design and of the grain require continual change in the direction of the cutting, and it is not practicable to keep turning the work, therefore one must become ambidextrous in using the tools. Learn at the start to work either right or left handed and to cut in any direction. In all cases remember to remove the wood by cutting, and never pry or tear it away. The picture of what is to be carved should be clear and definite in the mind, lest the work become mere mechanical copying of a pattern.

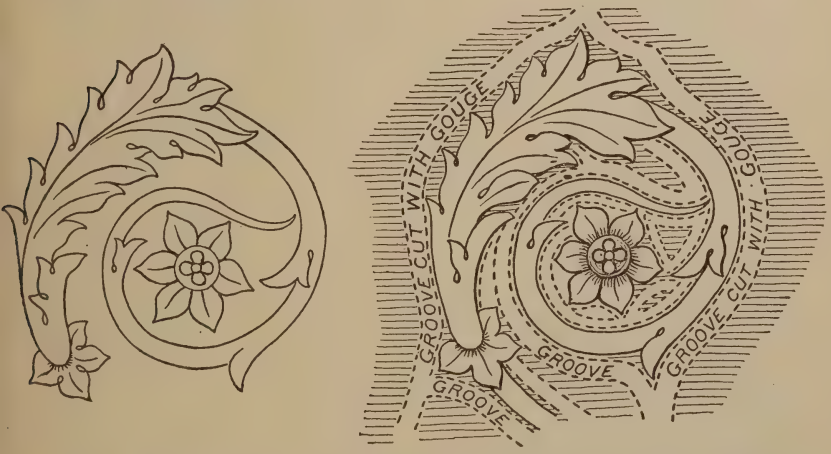


347. Regard the grain of the pattern and not that of the background. Thus to cut around the outline of the narrow band shown, cut in different directions as shown by the arrows.

348. A simple flat outlined design can be done by lightly cutting the outline with such tools as will fit (as shown at the left), cutting only deeply enough to clearly mark the outline. Try to use gouges of such curvature that the successive cuts will run together in smooth and flowing lines. Or the design can be outlined with a very light cut made with the V- or parting-tool (as shown at the right) or the veining-tool, which

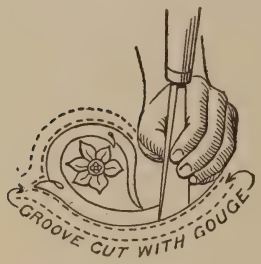


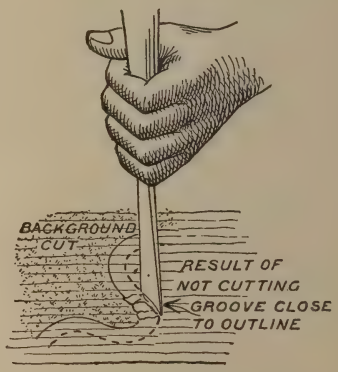
is a very small gouge. Then stamp the background with a carver's punch. For small places and corners use a nail filed from four sides to a point.



349. To cut a simple scroll (shown at the left), first roughly sketch the design with chalk or pencil, and then go over it

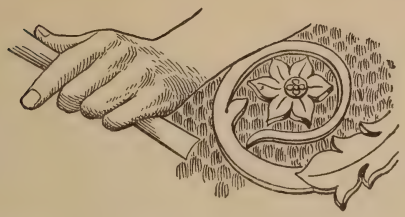
carefully with pencil. It is well at first to mark over the background, as the beginner is apt not to distinguish the design clearly. With a small gouge run a groove around the pattern, just outside of the line (shown at the right), cutting in different directions when the grain requires. In all cases when cutting angles or corners, whether to cut toward, or from, the corner or angle depends upon the grain of the wood. Of course you cannot cut cleanly from an inside angle with a gouge, but must finish by cutting toward the angle, or with some other tool.





350. **After thus roughly outlining the design,** carefully cut on the line down to the level of the background, as shown at the left. The mallet can be used for this. It is not necessary to have a gouge to fit every curve exactly. For an outside curve a gouge flatter than the curve can be used, and for an inside curve one "quicker" than the curve. As the groove first cut has removed most of the wood near the outline, the chips will readily break off in the waste wood, without damaging the part to be kept. If the grooving were omitted the slender parts might be broken, as shown at the right.

351. **The rest of the background** can now be cut away, using as large a gouge as may be convenient, and finally smoothed with a flat gouge. The angles and corners must be

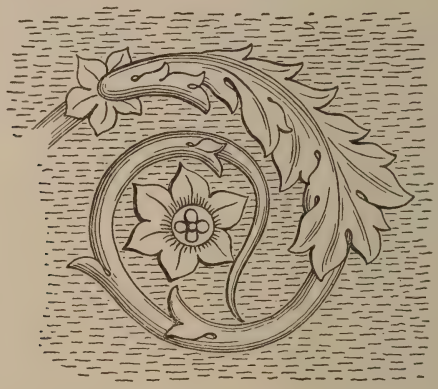


cut with whatever tool will best do the work, but the wood should in all cases be removed by clean cutting and not by prying. Do not try to make the background absolutely true, as if done by machine. The slight irregularity or waviness which naturally results from freehand work is proper in carved work. The background can be stamped as before, or, as is more commonly done, smoothed as nicely as may be with short cuts of a flat gouge.

352. **Little hollowing cuts** make a good background for many designs.

353. **After a design has thus been outlined** and the background cut the raised parts require to be shaped. In a design like that shown in 348 at the right, there is little to do but to cut down where the parts overlap. Sometimes the outline is undercut by sloping the handle of the tool outwards.

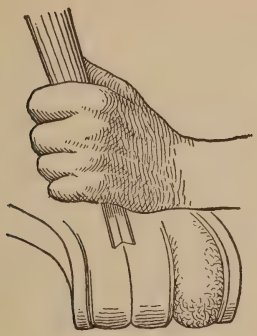
354. When the design is to be molded as shown in the illustration, for example, gouges of somewhat flatter curvature



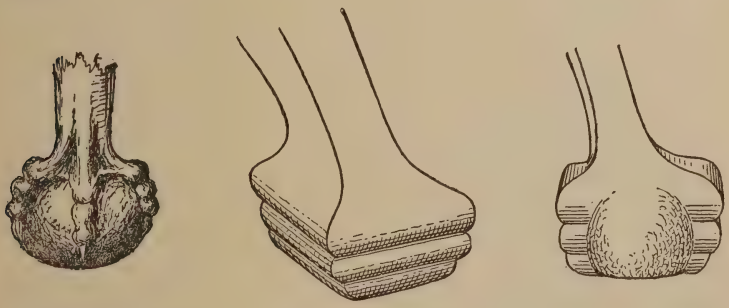
than those of the design are used. The cutting should be done with the grain, stopping and cutting the other way when the grain requires, on the principle shown (**347**).

The general process with work in high relief and odd-shaped or projecting forms is first to remove the superfluous wood, "rough out" the shape with such gouges as may be required, and then cut the details. Sometimes much of the waste wood can be removed by sawing. In roughing off the wood, begin at points distant from the final shape and work toward it, so that the waste wood only will break off, without danger of damaging the part to be saved. Sometimes waste wood can be quickly and safely removed by the use of the bits and bit-stock. When some part projects much above the general surface, a piece, or pieces, can be glued on and carved afterwards, but gluing is not to be recommended unless necessary. When the work is very thick and heavy, or one part much higher than the rest, building-up by gluing is sometimes the only practicable way.

355. To shape the end of the arm of a chair, first round the end with the band-saw or by hand, and then cut down



between the divisions of the design, as shown, thus removing the waste wood before trying to work the wood exactly to shape.

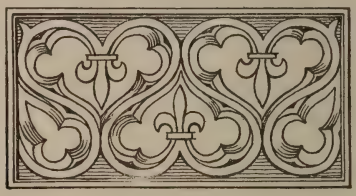


356. In cutting a clawfoot as shown at the left, much of the waste wood can be removed by sawing as shown in the middle illustration. The removal of the waste wood and roughing out can be begun as shown at the right, and the rest of the shaping done on the general principles already described.

357. In modeling with the gouge much effective work can often be done by giving a rotary turn or twist to the tool, causing a shearing cut (**77, 94**). Making a model first in clay or other plastic material is often a help.

In all cases try to have a sharp, crisp, clean-cut effect. The work should stand out boldly and clearly and not appear to have been laboriously scrubbed into shape.

358. With designs like tracery, on a background, the design can first be sawed out, glued to the background, and then carved. This saves cutting away the waste wood. Although



often done, this process is not to be advised, as a rule. Carvers usually prefer to cut away the background. This also avoids depending upon a glued joint. Open work patterns are sawed of course before modeling the surfaces. Simply sawing openings, as is often done, is in no sense carving, but merely scroll-sawing or jig-sawing.

359. Do not try to scrub carved work smooth with sandpaper. Leave it as the tool leaves it. A touch with sandpaper is sometimes permissible to remove a too sharp edge. Finish carved work either with wax or very thin shellac, never with varnish or a thick coating of shellac. A brush is the best thing for cleaning, rubbing over, and polishing carving.

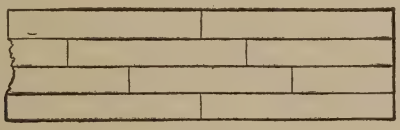
360. Norse or Scandinavian patterns are excellent for the learner. They cultivate freedom and boldness of execution, desirable for the beginner.

361. Chip-carving, or the cutting of incised patterns of a geometric character, is a mechanical and routine process compared with regular wood carving. While lacking the artistic possibilities and educating influence of true carving, it cultivates accuracy of eye and hand, and is suitable for borders or other decorations for a certain class of objects. The simple forms can be done with a chip-carving knife, or even a pocket knife. A little of this work is good training, but one can easily spend too much time on processes of this kind.

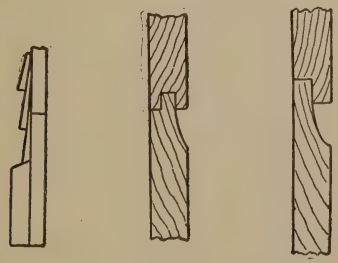
Chamfering. See 318.

CLAPBOARDING

362. Clapboarding. First put on door and window casings, corner-boards, and other outside finish. Begin clapboarding at the top. Lay the upper row by a line, marked with a straight-edge (**20, 21**), or chalk and line (**49-50**), using a few nails in the upper part only. Mark the ends accurately, using try square, and saw them carefully with a fine saw. Then slip the next row up under the first row until only the desired width is exposed. The width of the courses can be marked on a stick, on the outside finish of the building, or a clapboarding-gauge can be used.



363. Break joints, that is, do not have the joints of one row in line with, or very near, those of the next row or of the one above that, to prevent leaking, and penetration of cold. Nail the first row near the lower edge with clapboard nails. This will hold the second row in position while the third row is put in place, and so on. The thin edge of the upper row can be covered with a strip of board or moulding.

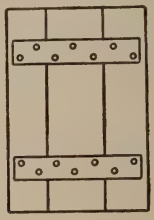


364. If a water table is used at the bottom, as shown, bevel the lower edge of the last row of clapboards to fit. Sometimes

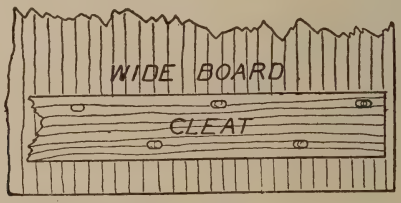
the clapboarding is continued to the bottom of the building. Siding is sometimes used. See also *Flashing* (**418**).

CLEATING AND BATTENING

365. Cleats or battens are used to fasten two or more pieces together, for stiffness or strength, to cover cracks, etc.



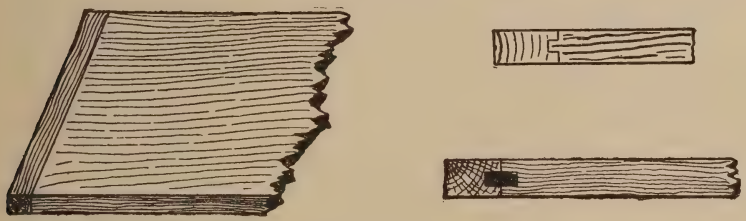
366. Side cleats, as for a door or wide board. Stagger the nails or screws (**213, 367**). Do not glue, because the boards will expand and contract and thus may break the glued joints (**747**). Nails or screws give some play to the pieces. Nails can be clinched (**216**).



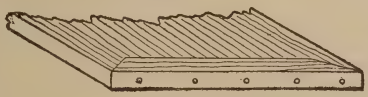
367. If a board is very wide, as a large drawing board, the screws can go through slotted holes in the cleats to allow for expansion and contraction of the wide board (**366**). These slots are sometimes bushed (lined) with metal.

368. End cleat, to be nailed. Screws do not hold well in end-grain (**224**). End cleats help to keep one board from warping, and will also hold two or more pieces together. For heavy work, side cleats are stronger, but not always desirable. An end cleat can be grooved to fit a tongue on the end of the

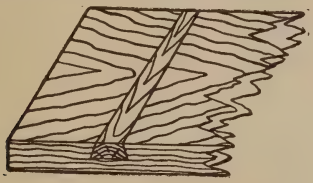
board, or both cleat and end of board can be grooved and a spline inserted (**526**). A dovetail can be used (**527**). Such work



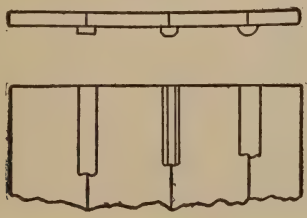
is best done by machine (**585,** etc.), but can be done by hand with the planes for the purpose.



369. Less common form of end cleating.



370. Dovetailed cleat, on underside or back side, for nice work. Also tapered slightly lengthways, so that it can be tightened. Metal cleats are sometimes inserted in kerfs or grooves on a similar principle.

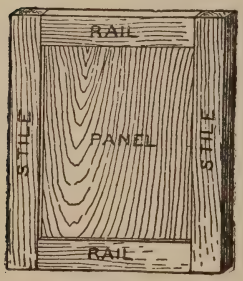


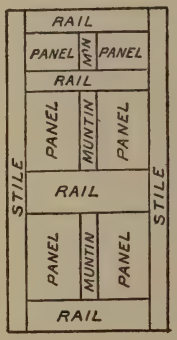
371. Battens for covering cracks. Used for buildings which are boarded vertically. Also for making surface panels and other inside finish. See **524,** etc.

Coping. See *Joints* (517, 518).
Crate-making. See 341.
Dadoing, see 463.

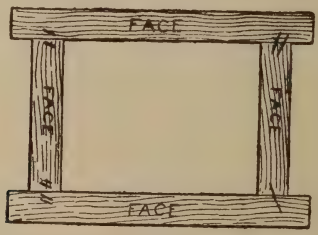
DOOR-MAKING AND PANELING

372. Doors and Panels are now made almost always by machinery.[1] In making the frame lay out duplicate parts together (70) and do all squaring and gauging from the joint-edges and face-sides (27, 72). The joint-edges should be the inside edges, the ones to come next the panel—so as to have the best edges at the joints.





373. Names of parts.

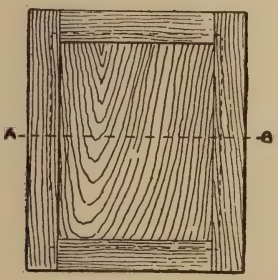


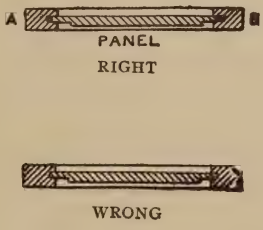
374. Mark joints to prevent mistakes when assembling (71). Leave the stiles a little too long (for convenience in working)

[1] For the simplest and cheapest way to make a rough door for a shed or a camp, see 366. Adding a diagonal brace makes such a door much stronger.

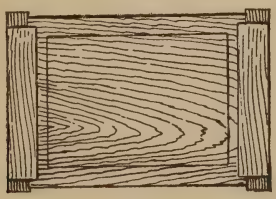
until after the frame is finally put together, when the projecting ends (lugs) can be cut off.

375. **Mortise and tenon** is the best joint for door- and panel-frames (see **467**). Dowelling (**500**) and even mitring (**508**) are used, but are less strong, usually (see **500**, footnote). Light doors and panel-frames often have tongued and grooved joints (shown below), made with the circular saw, or if necessary with hand tools, and fastened with glue.





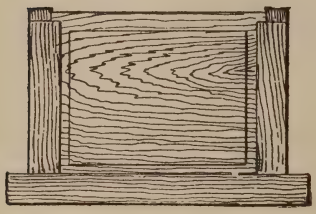
376. **A panel must have room in the groove** to swell and shrink (**747**), therefore the grooves in the stiles must be deeper than required to receive the panel. A panel must not be glued, but must be free to expand and contract across the grain. For nice work rub wax, paraffine, or tallow around the edge of the panel before gluing to prevent its becoming stuck. After all the parts are fitted, put the whole together, to be sure that everything fits, before applying glue. Then take apart.

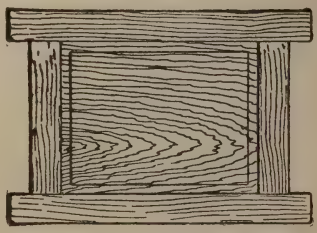


377. **To put together permanently,** first fit the panel in the grooves of the rails, without glue. A drop of glue is sometimes

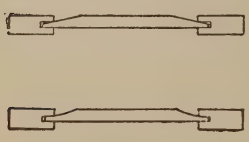
placed at the middle of the end of the panel or a brad driven later to keep the panel from working to one side.

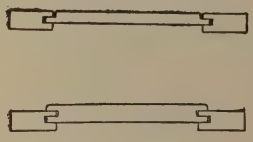
378. Next fit ends of rails to one stile with glue. See (**426,** etc.). Put the other stile in place temporarily, in order to clamp the glued joints properly. See **228**, etc.





After the glue is hard, glue and clamp the other stile. When the glue of this joint is hard, saw off the projecting ends (lugs) of the stiles, and smooth the surfaces. Both stiles can be glued at once under favorable conditions.





379. Common types of panels. The third form with flush surface will not fit perfectly at all times, because of shrinking and swelling. The last form is often used for the lid of a chest or desk, where strength is required. Unless the surface of the frame can be finished before putting together, shrinkage of the panel will show an unfinished strip. Panels are often bordered by a moulding, nailed to the frame, or, better, worked on the frame. Plywood can be used for plain panels.

380. Built-up doors, without panels, veneered in one smooth surface over a core of pine, chestnut, or other suitable wood, are now common. If done in the best way, such doors are satisfactory for as long a time as any glued-up construction

can be expected to last, but with inferior work or materials the result is soon very unsatisfactory. If you are building a house for your grandchildren, it will be safer to use the old-fashioned paneled doors.

381. **Simple paneling for the back of a bookcase** and in similar cases. Plywood (758), or even wallboard, can often be used for such work. If fitted loosely in a rabbet, plywood

and wallboard are often very satisfactory without any framework. Such panels should not be exposed to excessive dampness, and should be finished equally on both sides to prevent warping, etc., from atmospheric changes.

382. **Door hanging.** Fitting and hinging. Saw off the projecting stiles (lugs, 378). Plane one upright edge (the one to be hinged) to fit the jamb. Then hold door in position, tight against the top, mark where it is too large, and plane or saw to fit. Make the width (for a house door) about $1/8''$ less than that of the opening, and the height perhaps $1/4''$ less than that of the opening. Put door in place, fitting snugly against the frame on the hinge side and at the top, for a door is apt to settle a little. Slip something under the bottom to keep it in place. Mark with knife the places for the hinges on both door and jamb, or these can be marked first on a stick and transferred from stick to door and jamb. For house doors the upper hinge is usually about 6″ from the top and the lower one 8″ or 10″ from the bottom,—generally just below the upper rail and just above the lower one. Do not hinge opposite the end

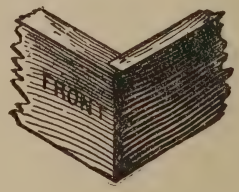
of a rail, because of the mortise and tenon. Heavy doors should have three hinges or butts. Mark the outline of the hinges on both door and frame, cut the gains (recesses for the leaves of the hinges), and screw on the hinges. The screws should have at least 1½″ of wood to screw into on the jamb, for house doors. If the door and frame are not flush, allowance for this must be made when gauging for one leaf of each hinge. The leaf on the door can be set a trifle deeper at the back side than at the front, to prevent striking the other leaf when closed. Each half of a "loose-pin" hinge can be fitted and screwed on separately and the pin put in or withdrawn at will. There are butt-gauges for hinge fitting. The lock edge of a door is sometimes slightly beveled to make a good fit and to allow the door to swing freely, but no door should fit very tightly.[1]

Dovetailing, see **519.**

Doweling, see **500.**

DRAWER-MAKING

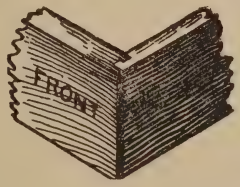
383. Drawer-making. The more accurately the case which holds the drawers is made the easier it is to fit the drawers so that they will run smoothly. Rub bayberry tallow on the running parts. The dovetail is the best joint for a drawer, but requires much skill (**519, 520**).



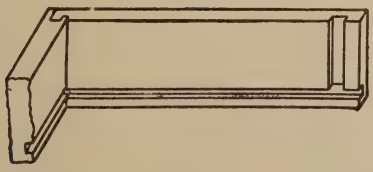
[1] Doors are framed, with panels, to prevent the swelling, shrinking, warping, and twisting which would take place if one or more wide boards were used, whether glued into one unbroken surface or not. The framing and paneling is also a decorative feature of course. The covering of other wide surfaces, walls, etc., with paneled work doubtless originated from the same reasons. As wood shrinks and swells a good deal in width, and but

384. Showing rabbeted joint at the front corners. Only suited for inferior work. See **461, 612, 613.**

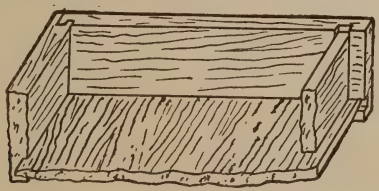
385. Showing combination of rabbet and dado. A good joint and much used. Inferior to dovetailing, but quickly



made by machine (**609**). Can be glued as well as nailed. See **465.**



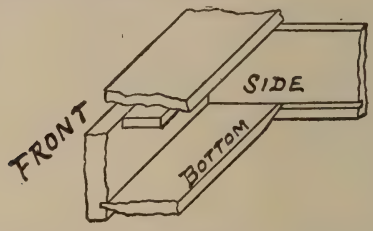
386. Showing dado (at the right) for the joint at the back. Also groove for the bottom. This can be cut with the plow or the circular saw (**609**). Dado extends only to the groove for the bottom. See **463, 464.**



387. Showing how the parts fit. The back does not reach quite to the top. The grain of the bottom runs from side to side of the drawer, parallel with the front. Smooth the inside

little in length, the frame of the door will alter its shape but little, because it is made of comparatively narrow pieces. The thinner panels, fitting loosely in grooves in the frame, can change their size without changing the size or shape of the thicker door frame itself. Whether there be one panel or many the principle is the same.

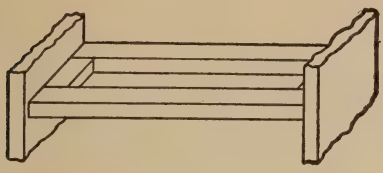
of the parts before putting together. The bottom is slipped in after the rest of the drawer is put together. Glue or nail bottom at the front edge only. This allows for swelling and shrinking of the bottom. Small corner blocks can be glued underneath at the front edge only.[1]



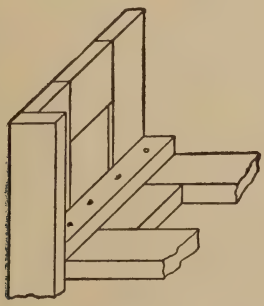
388. **Showing top of drawer-front** striking against a stop fastened to the framing above, to keep the drawer from being pushed in too far. The back being lower than the front, as just shown, allows the drawer to be removed entirely without hitting the stop. Also showing groove for bottom, a little narrower than the thickness of the bottom board, the under side of which is bevelled to fit the groove.

[1] Every part of a drawer, as well as of the whole case, should be *flat*. The front and sides should be got out to fit very snugly. The front piece is nearly always thicker than the sides, back, and bottom. If the front is $^{7}/_{8}''$, the sides are usually about $\frac{1}{2}''$ or $^{3}/_{8}''$, but the dimensions are governed by the size of the drawer. The front should be of the same kind of wood as the outside of the article, but the sides, back, and bottom are often made of whitewood, pine, maple, etc., though sometimes the same wood is used throughout.

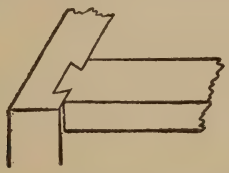
The order of the process is: 1st, to get out the pieces to the required dimensions; 2d, to make the joints for the sides, front and back; 3d, to cut the grooves for the bottom in the sides and front; 4th, to fit the parts together. Be sure that the drawer is rectangular (putting in the bottom will assist in this) and free from winding. Test with the framing square. A little trimming with the plane may be required to make a drawer run freely, but care should be taken not to plane away too much. It is easier to make a drawer which is narrow and long (from front to back) run smoothly than one which is wide across the front, but short from front to back. If it is a trifle larger at the back than at the front it will run best, as it will be less likely to bind or catch.



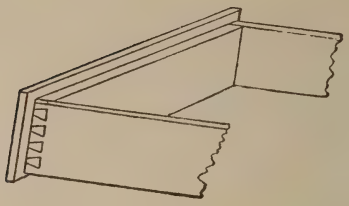
389. Showing frame on which drawer slides. This frame can be grooved (441), into the upright sides and for very nice work can be dovetailed (466).



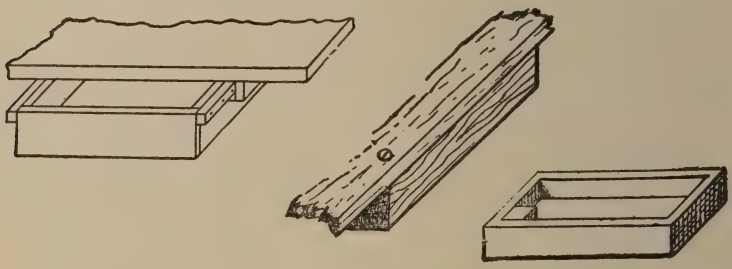
390. Showing guide adjusted so that the lower part of the side of the drawer will slide against it. Another guide is fitted at the other side and the drawer slides between them. Drawers are more dust proof and more inaccessible if the openings in the frames on which they slide are filled with panels. Drawers sometimes run in slides at the sides, and sometimes a slide is made from front to back under the centre of the bottom, to promote smooth running.



391. A dovetailed joint is the best way to fasten the cross stretcher above the drawer, if there is only one drawer, or above the top drawer if there are several.



392. The front of a drawer can project beyond the sides and bottom or top in a lip, which shuts against the front of the case,—a good way in some cases.



393. Simple ways to attach a drawer under a shelf, table, or bench. The way shown at the right is only suitable for a small, light drawer.

Filling, see **405.**

FINISHING

394. Finishing is a trade in itself. Essentials for good work: seasoned wood; very smooth surfaces; freedom from stains, hardened glue, grease, finger or pencil marks, and dust; a warm temperature, free from draughts and dust; and good materials.

395. To fill holes or cracks. *Small holes, etc.* Put a daub of hot glue on the smooth end of a piece of wood of the same kind as the article. With a sharp chisel, held nearly at right angles, scrape off enough fine wood-dust to make a paste.

Fill with this, and when thoroughly dry scrape off the surplus. For dark work, hold a hot iron close to a piece of stick shellac, of the same color as the work, over the hole, until it is filled to overflowing. Press with a hot knife. When hard, pare off the surplus and sand. Sticks of shellac of different colors can be bought.

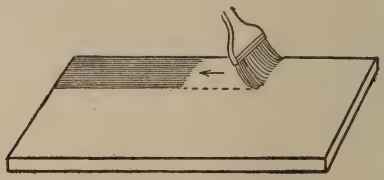
White lead putty can be used,—tinted a little darker than the work,—white lead mixed to a stiff paste with linseed oil and a little varnish. Before puttying, apply one thin coat of finish to stop the pores of the wood so that they will not draw the oil from the putty. Plaster of Paris mixed with shellac or thin hot glue, and colored if desired, can be used; also, colored wax, but the latter is not suited for large holes because it never becomes very hard. *Large holes, etc.*, should be plugged with wood (569).

396. **To remove a dent or bruise** when the wood has been compressed but not cut away, try wetting the bruise and placing a hot iron over it, with paper between. Sometimes wetting, allowing the wood to swell, and sandpapering, repeated several times, is sufficient.

397. **General principles.** For nice work, remove locks, hinges, and other hardware fittings before finishing. Erase pencil marks with rubber, and remove grease with benzine. Sand with No. ½ sandpaper, dust, sponge with luke-warm water, leave about two hours, sand with No. 0 or 00 sandpaper, and dust thoroughly. Very sharp angles at the edges are not desirable for finishing.

Place the surface to be finished in a horizontal position when you can. Face the light,—have the work between you and the light. Finish the least prominent parts first. Turn tables, chairs, etc., bottom up and do the under parts first, the upper surfaces last. Do edges first, then adjacent wider surfaces. Finish each part of the work separately. Stop where there is some natural break or line; never in the middle of a surface. Do two or three boards of a floor for the whole

length, then the next two or three. Pour part of the finishing material into a small vessel with a wire across the top over which to draw the brush, to remove the excess of liquid. In factories, finishing is done by dipping in vats, by spraying machines and rubbing machines.[1]



398. Work quickly. Begin *near* the end of the surface but not *at* the end. Start each succeeding stroke on the bare wood (or on the hardened coat previously laid) and brush toward the part already covered, to avoid "laps." After each stroke, brush back the other way to make the coating uniform. Make the final strokes with the grain of the wood. Give each coat of shellac, varnish, paint, etc., time to *harden*, before applying another. Haste is the cause of many failures in finishing.[2]

399. Staining. If you wish to color your work, the simplest way is to use a ready-made stain according to the directions of the makers. Common stains are usually mixed with water, linseed oil, turpentine, or alcohol. See general directions

[1] Padded saw horses are useful to hold the work. A turn-table, easily contrived, is good to secure the best light on the work. In finishing doors or panel-work, first do the panels (**373**), then the muntins, if there are any, then the rails, and finally the stiles, because in this way you wipe out or cover any daubs or "runs."

[2] Applying a second coat before the first is fully hard excludes the air from the under layer, and prevents its drying as it should. This also often leads to cracking of the outer layer. You can find an extreme illustration of this principle in some old shop where a convenient place on the wall has been taken against which to slap and work brushes. You may find daubs of old varnish or paint, perhaps an inch thick, made up of hundreds of layers slapped on before the previous ones were dry, the inside remaining soft after twenty years or more.

(397-8). Stir stain thoroughly. Wipe the brush a little but have it quite full, and apply *quickly* to avoid laps and streaks. For nice work, try the stain on a piece of waste wood of the same kind as the article, because stains act differently on different woods; and leave for a day, to allow for any chemical changes, for there is a good deal of chemistry about some kinds of staining. Earthen or glass vessels are usually best for holding stains.

400. **Water stains.** For most work, these are the best for the ordinary user, if properly prepared. They are cheap, easy to apply, penetrate the wood more than oil stains, do not obscure the grain of the wood, and usually give good results. The water raises the grain of the wood, however, therefore you must sand the work carefully after staining, or dampen it and rub down the raised grain with fine sandpaper before staining. A good way is to stain, then give a coat of *thin* shellac,[1] dry, and then sand lightly with fine sandpaper.

Water stain penetrates best if wood and stain are warm. If part of the surface is sapwood, sponge that part with water before staining. Use a thin coat of shellac after staining and before filling. A wide brush is best. Sponge with water ahead of the stain if it is absorbed so fast as to lap. Rubbing with fine sandpaper while the work is wet will sometimes remove a dark lap. If end-grain stains too dark, thin stain and do end-grain first.[2]

401. **Oil stains** are easily mixed (or bought prepared) and easily applied, but they do not penetrate the wood so well as water stains, sometimes obscure the grain and give a daubed and muddy appearance, and frequently fade. They should be thoroughly rubbed in and the surplus rubbed off. If a filler (405) is to be used, use it before the oil stain, for rubbing

[1] One part common shellac thinned with six or eight parts of alcohol.

[2] In place of the regular prepared water stains, any pigment or coloring substance which can be dissolved in water, or even mechanically mixed with it, can be used; but prepared stains are cheap and reliable.

off the filler may injure the staining. Common paint (without gloss), thinned with turpentine, applied with a brush, and thoroughly rubbed off with a cloth, makes a simple, cheap stain for common work. Stains made with naphtha, turpentine, etc., penetrate deeper, and are more transparent when wiped off, than if made with linseed oil alone.

If a thick oil or water stain leaves laps, try going over the surface again with the same stain thinned one-half, or even merely dampening near the edge of the laps. Oil stains are good for the insides of cabinets, bookcases, etc., and should be a little lighter in color than the outside. Apply oil stains, like water stains, quickly. If the end absorbs too much color, thin with turpentine, and do end-grain first. If part of the surface is sapwood, sponge the sapwood with turpentine or naphtha before staining. Do not sand after an oil stain. Oil stains should be thoroughly protected by shellac, which can be followed by varnish, for the color to last.

402. Alcohol stains can be applied quickly, but are more expensive, less simple to apply, and should be thoroughly protected by shellac, which can be followed by varnish, to preserve the color.

403. Varnish stains are easily applied, but are not desirable for nice work. The color does not penetrate the wood, which is easily exposed by bruising, and the grain is obscured.

404. Stains due to chemical action. The rich darkening and mellowing given by age can be easily secured with some woods. Articles made of oak or chestnut and cherry can be kept for some time in a tight box or closet with a dish of strong ammonia on the floor ("fuming"),[1] or can be washed with

[1] Oak and other woods contain tannic acid in varying quantities, therefore it is well (for this is a chemical process) to apply a solution of tannic acid and pyrogallic acid before fuming. Schmidt recommends using "one-half ounce of the former, and one ounce of the latter to the gallon of water." After fuming, apply hot linseed oil. Rub in thoroughly and repeat the process. After some time, give a thin coat of shellac, and finally wax, or varnish, can be used.

ammonia. The washing raises the grain, which must be rubbed down with fine sandpaper. Mahogany and cherry can be washed with lime water (solution of common slaked lime in water), or with a solution of bichromate of potash in water. When dry thoroughly clean the work in all corners or crevices, and sand carefully. Bichromate of potash gives oak a brown color. Such methods do not obscure but bring out the beauty of the wood.[1]

Dipping. Small articles can well be stained by dipping (**416**).

405. Filling. If the wood be coarse-grained, like oak, chestnut, ash, mahogany, walnut, etc., brush it thoroughly and fill the pores with a paste filler of suitable color and of the consistency of varnish. Keep well stirred and rub thoroughly, *with the grain*, into the wood with a stiff brush. After it begins to set, rub off the surplus thoroughly *across the grain* with burlap or some coarse material. Let dry for two or three days. Clean all interior corners and angles thoroughly with a

[1] The variety of stains is almost endless. For a common grade of work, asphaltum varnish, thinned with a large proportion of turpentine, gives varying shades of brown according to the proportion of turpentine. Add a very little linseed oil. Extract of logwood in hot water also gives a brown color. Walnut crystals can be used for cheap work. Schmidt recommends using about six ounces of crystals to one gallon of hot water, and if the wood be hard, adding an ounce of sal-soda. In case of dipping, the tank must be kept filled with stain of uniform strength.

For black, the simplest way, for common work, is to use paint, ivory black, or bone black thinned with turpentine. Even lampblack can be used. Black shellac (colored with lampblack) can be applied, but this does not penetrate the wood, however, and bruising will show the lighter color underneath. For nice work ebonizing is the proper way. Cherry, birch, maple, beech, apple, pear, ebonize well. Apply solution of logwood, and wash with vinegar in which iron filings have been soaked, or a black analine dye can be used. Schmidt recommends: "Boil one pound of logwood chips in two quarts of water, or one ounce of logwood extract (solid). Brush the hot solution over the work, giving it a second coat when dry. Allow this to stand at least twenty-four hours, and then coat with a solution of one ounce of green copperas (sulphate of iron) to one quart of water. Let this dry in a warm, well-lighted place."

pointed stick or some tool without rubbing through the edges. When hard, sand the surface carefully. Liquid fillers can be used, but are not so good as paste, as a rule. To prevent end-grain being too dark, thin filler and fill end grain first. Close-grained woods like pine, whitewood, basswood, poplar, maple, beech, birch, sycamore, cypress, cherry, gumwood, etc., do not require filling. If one should be needed, shellac is good. You can buy prepared fillers of the desired color. Those made with silex are the best. To thin fillers add turpentine or naphtha a little at a time, stirring thoroughly.

406. **Shellac** (solution of lac in alcohol) is probably the best varnish[1] for the beginner to use at first, for furniture and other indoor work. There is no nicer finish, unless perhaps wax. Water is injurious to it. Keep shellac in glass or earthenware. Where the orange color is unsuitable, white shellac can be used. For black work, black shellac. Shellac must not be used over varnish for the alcohol will injure the varnish, but varnish can usually be used over shellac. Shellac should be quite thin and flow freely from the brush. See general directions (397-8). Use a flat bristle brush. Three or four thin coats are better than two thick ones. Thin with alcohol only. Denatured or wood alcohol can be used if necessary. Shellac dries very quickly because it is cut with alcohol, therefore work rapidly and carefully without going back over the work to patch spots. Lay it on as well as you can and leave it. Give it at least twenty-four hours to harden. Lightly skim over the surface with fine sandpaper. Curled hair can be used. When rubbing down with sandpaper, use the paper with the fingers because you are smoothing the finish and not flattening the surface. For fine work split the sandpaper[2] by

[1] Shellac is, strictly speaking, a kind of varnish, but it is so different from many kinds of varnish in common use, that it is usually spoken of as shellac, in distinction from what is popularly known as varnish.

[2] Special finishing sandpaper for rubbing shellac and varnish is very fine grained. Some is double surfaced, ready to be split. oooooo garnet paper

removing the outer layer of paper so that it will be more flexible, and dampen with oil. Wipe thoroughly, apply a second coat, and so on. When you have a sufficient body of shellac on the wood, rub it down with a bit of felt on which is a little powdered pumice wet with thin oil. Rub with the grain evenly and carefully lest you rub through the finish. Wipe off with a soft cloth. Use a toothbrush or something similar for rubbing carved work, or places where a felt pad cannot be used.[1]

407. Varnish. See general directions (397-8). Varnish dries more slowly than shellac, so more time can be taken. Keep the room warm and free from dust, because varnish will be spoiled by a shower of dust long after shellac would be dry, and have the varnish slightly warm. There are many kinds of varnish, for many purposes. Only the best grades are satisfactory for good work. For work to be exposed to the weather or to water, use spar varnish. A coat of thin shellac is often used before varnishing. The temperature of the room, of the wood, and of the varnish, should be not less than 70° for the best results.

To thin varnish, mix separately a small quantity of varnish with twice the quantity of turpentine. Leave for a day. Add to the main body of varnish until it works freely.

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is good for fine work. The flexibility of the split paper prevents glazing and scratching.

[1] *French polishing.* A wad or pad of woollen cloth or cotton wool is made, and on this is poured thin shellac, adding whatever alcohol may be necessary. This wet pad is then covered with a piece of clean linen, a drop of linseed oil put on the outside to prevent the shellac from sticking, and the pad quickly passed over the surface with a circular motion, or with longer strokes in the form of the figure 8. After doing this for a while a very thin coat will have been deposited. This is allowed to dry for a short time, when the process is repeated, until a sufficient body of the polished finish has been formed. The details vary with different finishers. It is quite easy to polish a small flat surface, the arm of a chair, for example; but it is hard for a beginner successfully to polish a large flat surface, like a table-top. A coating of shellac is usually put on in the ordinary way first and skimmed over with sandpaper, to save labor in the polishing process.

Use a flat brush (fitch, or badger, is good) fairly full of varnish. Apply freely and quickly, without working over the surface. If too much varnish collects at any spot, wipe most of the varnish from the brush, and take up the surplus with a light stroke. For rubbing, water or oil can be used. With water, wet a felt pad and dip in pumice or tripoli (or sprinkle the powder on the surface). After rubbing, sponge surface with water and wipe clean. With oil, use pad or felt, burlap, or webbing, pumice, and rubbing oil. Wipe clean. Rotten stone with oil gives a soft polish. You may rub down or polish the extreme ends of large surfaces across the grain first, then lengthways. Clean corners carefully. Use a toothbrush, or something similar, for rubbing and cleaning carved work, or where a pad cannot be used. The palm of the hand is often used for the final smoothing, after rubbing down. The general principle of rubbing is that, as the surface becomes finer, finer materials should be used.

Cork linoleum and rubber make good facings for blocks for sanding or rubbing. Thick felt also makes a soft block. For a fine dull-rubbed finish for nice work, use a light-bodied transparent varnish.

Cover varnish pot when through, and keep brush hanging in varnish or in turpentine so as to cover the hairs, but without resting on the end; or wash brushes thoroughly in turpentine (gasoline can be used), or with soap and water, rinse and dry. Vessels can be bought arranged to protect both varnish and brush. Keep brush and varnish dish **clean**, so that there will be no particles of hardened varnish to be deposited on the surface, which is a frequent cause of poor work.

Dipping. Small articles of some kinds, toys for example, can often be dipped to advantage. See **416**.

The air-brush (spraying-machine) is the last word in finishing. It applies the coating not only much more rapidly, but more uniformly, more smoothly, and more cheaply than hand

brushing. These machines should be used according to the directions for each machine. *Rubbing machines* are also efficient.

408. Wax gives a beautiful finish, soft and lustrous. It shows spots, however, and for articles in constant use requires renewing often, but this is easily done. The surface must be *very* smooth and *free from defects*. A thin coat of shellac, lightly rubbed down with fine sandpaper, makes a good under coat on new work, before applying the wax. Use prepared wax. Put a little on a piece of doubled cheesecloth. Fold like a bag and pass over the surface to distribute the wax evenly. Leave for a short time and then polish with brush, soft cloth, felt, or carpeting; but follow the directions on the can. Colored wax can be used. To polish floors, rub with a weighted brush or a heavy weight covered with carpeting, pushed back and forth like a carpet-sweeper. Wax can be colored with aniline colors soluble in oil, which can be bought of the dealers, dissolved in heated turpentine and mixed with the wax by melting the latter.

409. Oil finish. An excellent soft finish for some close-grained hard woods, but involves more repeated rubbings than most people are willing to give. Unless thoroughly done, it is apt to be greasy. It darkens the wood in all cases. Use linseed oil thinned with turpentine and rub repeatedly at intervals until a good finish is obtained—a good finish for kitchen-floors, if renewed at intervals. Paraffine melted into the wood with a hot iron is used for kitchen floors, but involves more work to apply.

A good polish for small objects like handles, etc., is made by adding a small proportion of boiled linseed oil, perhaps 1 part to 5 or 6 of shellac. Shake, rub on, and polish with cloth.

410. Wood lacquer.[1] To what extent wood lacquer, which may be called, roughly speaking, wood fibre (nitro-cotton or

[1] Modern wood lacquer should not be confused with the well-known lacquers used by the Orientals. Professor Morse, speaking of the best

cellulose) in liquid form, may take the place of varnish cannot be foretold, but its use is increasing to a marked degree. Among the advantages claimed for it are durability, hardness, flexibility; resistance to heat, cold, and moisture (thus hindering warping, expansion, and contraction), to scratching, cracking, etc. Also, repeated coats can be applied in the same day, at intervals of two hours. Rubbing can be done after twenty-four hours or even less. But little rubbing is required.

The wood is prepared, stained (water stain is preferable), filled (a silex filler is best), as for a shellac or varnish finish. The wood lacquer is then applied with a sprayer. Articles of suitable size and shape (toys, for example) can be dipped. Wax can be used for a final finish. You are advised to procure some wood lacquer and experiment with it, following the directions of the manufacturer, and you will be likely to find many uses for it. It can be thinned and applied with a brush, but the best results have been obtained with sprayers or by dipping.

Reference for finishing: *Problems of the Finishing Room*, WALTER K. SCHMIDT.

Summary. Seasoned wood, clean, smooth, dry, and free from dust. Remedy defects. Room and wood warm and free from dust. Water stains, and those due to chemical action, usually best. Silex filler for coarse-grained woods, well worked in and thoroughly cleaned off. Thin coats of shellac or varnish better than thick ones. Apply quickly and evenly. Allow abundant time for hardening. Rub down carefully with sandpaper or pad and pumice, lubricated, etc. Rub wax thoroughly. Wood lacquer durable. See also **397, 398.**

411. Refinishing old work. If the surface is in bad condition, scrape to the wood with cabinet-scraper, and sand thoroughly. A chisel, or a plane-bit, used as a scraper, often helps

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lacquer work of the Japanese, tells of an article being given one coat a year, the finest work having twenty-one coats, and the artist rowing out to sea for miles each time to make sure that all dust is avoided.

in awkward spots. Varnish remover can be used according to the directions on the can, but all traces of it must be removed by washing or with scraper and sandpaper, lest the finish be ruined. If removal of the old finish is not necessary, clean with soapsuds, and rub with fine sandpaper, split, using oil. Pumice can be used. Use a stiff brush (nail- or tooth-brush) for cleaning out angles and carved work. Finally, thoroughly clean and wipe the surface, and apply the desired finishing coats.

Cleaning and brightening old finish. Mix equal parts of linseed oil and turpentine with a very small quantity of Japan. Rub well with flannel and rub off. This makes scratches less conspicuous and freshens the finish for some time, but is not a substitute for refinishing a badly defaced surface. Wax, rubbed to a polish, is often a good reviver.

412. **Painting.** See also **397-8.** Be sure that the wood is both seasoned and dry, else it may decay, or the paint peel, or both. Use only the best grade of paint for good work. Give knots, or streaks of resinous matter, a coat of shellac, before painting, to "kill" them and prevent colored spots showing later. Remove grease with benzine. Also remove all dirt and dust. It is a bad plan to paint in damp or frosty weather. On new work the first coat (which is the most important) should be thin, for the oil in the paint will be drawn into the wood quickly.

If the paint be thick, the oil will soak into the wood leaving the pigment on the outside too dry. Work the first coat well into the wood. Take but little paint on the brush. Stretch a wire across the top of the paint pot to draw the brush over to remove any excess of paint. Begin at the highest point, or the end farthest from you, to prevent dripping on the freshly painted surface. Draw the brush back and forth to spread the paint as evenly as possible, and work it in. Paint with the grain of the wood or the long way of the work. Use a large brush for large surfaces; finishing corners, mouldings, and

edges with a small brush. Try not to leave any part of a surface until another time, or it will be likely to show a "lap." Stop where there is some natural line or break in the work.

Paint door and panel work in the order shown in **397,** footnote. In work to be exposed to the weather, paint joints, tenons, mortises, shoulders, etc., with white lead, before putting the work together, for the wood quickly decays if the dampness can enter the joints. Old weather beaten wood and a rough surface take more paint than new wood and a smooth surface. Thin paint more in cold weather than in warm. Warm canvas before painting and when it is laid for a floor, roof or deck, lay it in a heavy coating of white lead.

Cracking, checking, and peeling are often due to not allowing time enough for drying between coats. Give the first coat plenty of time to dry,—several days at least, a week is better. Then putty the holes and cracks. Never use putty before the first coat is hard, for the pores of the wood will absorb the oil from the putty and leave it dry and crumbly.

Many experienced painters consider it better to mix white lead and linseed oil, with whatever coloring may be required, than to use ready-mixed paints, but the latter are commonly used for convenience and to save time. Follow the directions on the can. Thin paint with linseed oil or turpentine. An excess of turpentine injures the durability. Use oil only, or chiefly, in thinning for outside work. In some cases for some woods (as cypress, hemlock, hard pine, and other hard resinous woods) turpentine is used for outside work. Turpentine causes the paint to work freely and smoothly from the brush and gives the soft, "flat" appearance often desired in inside work. Shiny inside paint, while often in vogue, is more liable to check and crack than a flat or dull finish. Use very little dryer, and add it only to the quantity to be used at the time. Zinc paints are usually considered inferior to lead, but the addition of a proper proportion of zinc oxide to lead paint is thought best by many.

To mix paint, stir very thoroughly. In mixing or in stirring prepared paint, stir the lead or the heavy deposit in the can very thoroughly with but little of the oil. Then add any color required for tinting and finally a little dryer, if needed, then the rest of the oil, and sometimes a little turpentine. Pour back and forth from one can to another. It is improved by straining through cheesecloth.

Red lead is good to paint iron. Black Japan varnish and asphalt are also used. The iron must be dry and it is better to have it warm.

413. When leaving paint, pour a thin layer of linseed oil over the top to exclude the air. Clean brushes with kerosene or turpentine. For fine inside work sandpaper between coats. Keep a rag with you while painting to wipe up any spattering at once. Old paint, if loose, can be scraped with knife or scraper, or sandpapered off and steel wool can be used; but if in very bad condition, is usually burned off with a blow-torch. In repainting old work, first touch-up the worn and bare spots, before painting the whole surface. Flat brushes are better than round except for coarse work.

Brushes which are to be laid away should be washed in strong soapsuds, rinsed, and smoothed into shape. Temporarily, they can be kept in oil or even water. Clean hands with kerosene, paint oil, or lubricating oil. Fine softwood sawdust makes an excellent towel.

414. Enameling. For the best results apply successive coats of paint of the desired color, carefully rubbing down each coat with fine sandpaper or even pumice and water until a sufficient body of rubbed down paint has been formed on the surface. Then finish with enamel, applying it like paint or varnish, as already shown. For very nice work many under coats are applied to give a solid and durable body.

415. Water colors. Toys and the like are often colored with water colors, of which various kinds are for sale. These

should have one or more coats of varnish or shellac, also, over the water colors, for protection.

416. Spraying and dipping. Much painting is now done by spraying the paint on the surface with spraying machines, and by dipping in vats of paint. Dipping is very convenient for small articles. Very small objects can be held in a wire basket while being slowly dipped. Larger articles can be held by wire. All can be drained upon a mesh or wire screen, with a trough beneath to return to the dipping vat whatever paint may drip from the articles. The proper consistency of the paint for dipping can be learned by experiment.

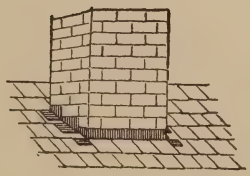
417. Putty. Commonly made of whiting and linseed oil. A large proportion of white lead worked in makes it much better. To color putty, stir the coloring matter in a little oil and then knead it into the putty until the whole is colored. Keep putty under water, not in paper. If too soft wrap in paper and the surplus oil will soon be absorbed. Use a square bladed putty knife for flat surfaces. For nice work, not painted, see **395, 569.**

FLASHING

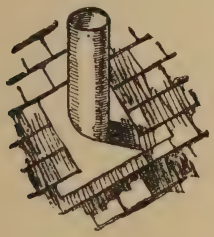
418. Flashing. Protect the tops of window and door-casings, and similar joints, by strips of sheet lead, slipped up under the clapboards, or the shingles, to cover the crack where the window casing joins the side of the building. This will shed the water. Tonguing and grooving can be used. Flash in a similar way where roofs or other attachments join a building. To flash a brick chimney, separate pieces of lead are inserted in joints of the brickwork so as to overlap each other as shown above. The pieces of lead are overlapped by the rows of shingles. Lay the flashing between the rows of shingles so that the water will run off on the outside without getting under the shingles.

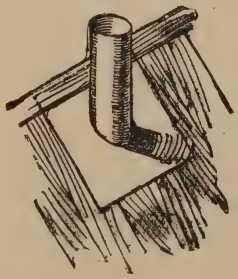
Flash valleys, where two roofs meet, on the same principle; or with one strip of metal running the whole length of the valley, in which case the shingling does not begin for some

distance from the angle of the valley, the metal acting as a gutter. Zinc and even tin can be used for flashing, but are



inferior to lead. Copper is good but expensive. In snowy climates the eaves also are often covered with metal to prevent snow water "backing up" from alternate thawing and freezing. The lower row of shingles begins just below the upper edge of the metal.



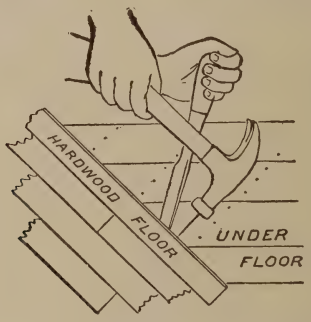


419. **Showing flashing for camp,** or temporary structure, slipped under shingles at the top and sides and over them at the bottom, to shed the water. Smoke pipe and flashing are soldered together. For board or fabric-covered roof, the

flashing can be slipped under the saddle board at the top, or under a strip of the fabric.

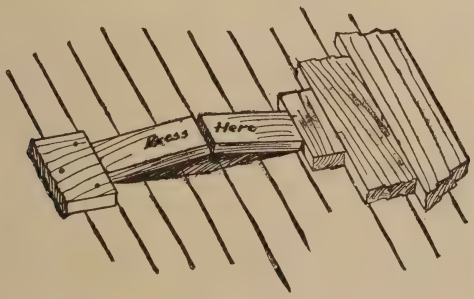
FLOOR-LAYING

420. Floor-laying. Hardwood floor-laying is a trade in itself, but the amateur can lay a good floor with care. The under floor of soft wood must be even, without high or low spots, and be firmly nailed. It is best laid diagonally or at right angles to the upper hard wood floor. An old floor often has to be leveled with an adze or other tools, or have the low spots built up or "shimmed." Sometimes furring-strips are laid and carefully lined up to give an even and springy surface. Lay sheathing-paper over the lower floor if it is cold underneath. Hard wood floorboards are matched (tongued and grooved) on the edges and ends, are hollowed or "backed-out" on the under sides, and holes are bored for the nails. They are slightly narrower on the under side than on the upper, and the ends are slightly undercut (**535–6**), to ensure tight joints on the upper side. Lay the upper floor lengthways of the room when the construction and the arrangement of the building will allow. Line the first row as straight as you can, but do not nail it against the wall. Nail at the edge near the wall, and cover the nailing with quarter-round moulding.

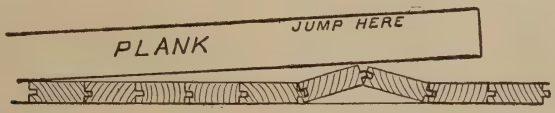


421. Draw each row tightly against the one last laid with a chisel, as shown, and hold in position while nailing. Use a

waste piece of flooring for blocking if necessary to pound the edge, as shown for sheathing (**525**). Drive nails at an angle of 45° to 55° and about 16″ apart, for boards $^{13}/_{16}$″ thick, and not nearer than 6″ to the ends, unless necessary. Drive the first nail or two in each piece slanting toward the end where it butts against the piece just laid, to draw the end joint together (**536**). Eight-penny cut flooring nails are excellent (**209**), though steel wire ones are often used. For $^{3}/_{8}$″ flooring smaller wire nails are used, about 9″ apart.



422. The principle of the toggle-joint used to force a crooked piece into place.



A

423. Another way to make tight joints. The boards at the sides are nailed, and the key-boards (A) placed as shown. A plank is laid to extend over the joint, which is closed by jumping on the plank.

424. Have end joints come at different parts of the floor. Saw ends as squarely as possible, using try square. A *very slight* undercutting can be made, but if the floor is to have very hard wear, a square joint may be better. A slight tap at the other end will close an end joint, when a hard blow will cause a recoil. The final smoothing of the floor is now

done with portable sanding machines. It can be done with plane and scraper, but is hard work. With fine-grained wood, apply a coat of thin shellac and then wax or varnish. See **394,** etc. With coarse-grained wood like oak, first fill with a paste-filler.

A common fault is to lay boards taken directly from a cool, damp storage place. Later the heat shrinks them, leaving open joints. The room should be warm, the boards thoroughly warm and dry, and should have been kept so for some time before laying. Maple, birch, beech, red and white oak, and rift (quarter-sawed, **739**) hard pine make good floors. Quarter-sawed yellow pine, Douglas fir, and other woods are also used.

GLAZING

425. Glazing. *Old work.* Take out sash and place flat if possible. Clean off old putty with chisel, knife, or hot iron. Spread a thin layer of putty on the rabbet (**567**), and bed

the glass on it by pressing gently. Hold glass with glazier's points of zinc, which will not rust, easily driven by sliding a chisel sideways over the glass. Apply the putty, and smooth it with a square-ended putty-knife, using a drawing-stroke. *New work.* Prime the rabbet with lead paint and let it dry before setting the glass, to prevent the oil in the putty being absorbed by the wood.

Common glass can be cut with cheap glass cutters. Use a straight-edge, and score the line once carefully, being sure

that the ends are scored. Hold near line, and bend glass a little until it breaks. If it does not break, rap it slightly, at the end near you, on the smooth side under the scratch, and try again. Trim off any projecting places with the slots on the cutter.

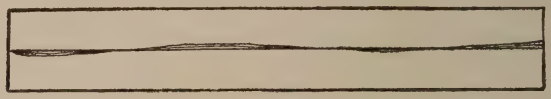
Common glass is single or double-thick. Plate glass is thick, ground flat, and polished.[1]

GLUING

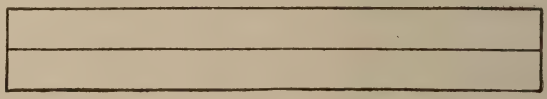
426. Gluing. Glue seasoned wood only. Also, use pieces of about the same degree of dryness, or one piece will change its size or shape more than the other (**747**), which will put too much strain on the glue. For example, it is unwise to glue together a piece taken directly from a hot, dry storage place or a drying-kiln and a piece from a damp shed, even though the latter may have been very dry once. In such a case keep both pieces for a while in a warm room before gluing. Also, do not glue together quarter-sawed (**739**) and plain sawed (**736**) stock, for the latter shrinks, swells, and curls more than the former, which puts an unequal strain on the joint. Fine-grained and coarse-grained pieces do not glue together so well as those of similar fibre. Also, join heartwood to heartwood and sapwood to sapwood when possible. Have the grain of the pieces run in the same direction when you can.

[1] The rabbet of a mirror frame must be colored black—also of any frame to hold plate glass—on account of the reflection. A small piece of plate glass can be held in place by strips, but a large plate, as for a mirror, should be fastened by little pieces of soft pine, one or two inches long, bevelled on one side. These short pieces, glued on one side, and lightly pressed into the crack around the glass, wedge the glass in place securely and, owing to the softness of the wood, not too rigidly.

427. A weak joint. The surfaces only touch in spots, and elsewhere are held together merely by a thick layer of glue,



like marmalade in a cracker sandwich, and will probably come apart. See *Plane* (**132**, etc., **146**).



428. A good joint. The surfaces must touch everywhere, because the pieces are held together by the glue which penetrates the wood on each side of the joint, not by a thick layer of glue between the pieces.

429. Common glue is made from refuse animal matter,—some glue from fishes. It comes in flakes, or ground, to be dissolved and used hot. Also in liquid form to be used cold. *Hot glue.* This is the best if you can keep it hot, and the wood and the room warm, while gluing. Buy the best grade for good work.[1] Break in small pieces and soak in cold water for six or eight hours. Then place in the inner vessel of a glue pot, which must also have an outer vessel for water, like a kitchen double-boiler, to prevent overheating the glue. Put water in the outer vessel, heat until the glue melts, and keep the temperature at that point so long as you are using the glue. If the glue cannot be soaked, start with cold water and raise

[1] Good flake glue has a clear appearance, is tough, bends, does not break easily, and breaks evenly without splintering. If the smell is at all offensive, throw the glue away. Good glue will absorb much water without dissolving, while poor glue will dissolve. To test the strength, glue end wood under pressure after sizing (**433**), leave until hard, and see how much force is required to break the joint. Ground glue is convenient and saves time, as it can be prepared in half-an-hour, but unless you buy from a reliable maker or dealer it may be safer to use the flake glue, because adulteration of ground glue is less easily detected when buying.

the temperature gradually. Overheating is very injurious. The glue should have the consistency of thin cream. It should drip from the brush. The entire quantity of water should be put with the glue before melting and not added afterward, for the best work. A thin slip of wood is sometimes better than a brush for applying glue. As kinds of glue vary, it is impossible to state the exact quantity of water which should be used with every kind of glue in the market. If no quantity is specified, try a small experimental melting, adding water if necessary, until you find the right quantity, for future use. Glue loses strength each time it is re-melted, so for important work make it fresh, and keep the glue-pot clean.

430. **Toothing,** that is, scratching the surfaces to be glued with a toothing-plane (134, footnote), or otherwise, has been practised for ages, and has been supposed to give the glue a stronger hold on the wood than if the surfaces are smooth, on a similar principle to that used in lathing and plastering walls; but the Forest Products Laboratory reports that there would seem to be no advantage in tooth-planing wood for gluing purposes. See (580).

431. **Glue first and plane afterwards,** if possible. For example, in case of a table-top, fit the edges of the rough boards, and glue them together. After drying plane the surfaces as one piece to the required thickness. Not only must the surfaces fit together, but they must be pressed together so hard that the glue will be forced into the wood, and kept pressed until the glue has set thoroughly. Except with very small pieces, the more pressure you can apply with clamps, hand-screws, or otherwise, the better the glue will hold. Fit clamps and hand-screws (228, etc.) before beginning to glue, and place them where you can reach them at once, because glue cools so quickly that no time can be wasted in adjusting clamps. Be sure that the glue is hot, the wood warm, and the room warm and free from drafts. Then work as fast as you can. If

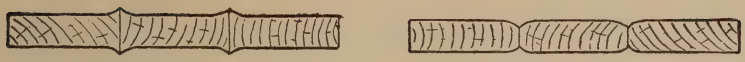
the glue cools before the pieces are pressed together, the work will be spoiled. With complicated work have someone help you. With very small pieces excessive pressure should not be applied. Little pieces of soft wood can often be rubbed into place and pressed with the hand for a few moments, until the glue has set enough to remove the pressure, but such joints should not be disturbed for several hours. There is usually no danger of too much pressure; but it sometimes happens, making a "starved" joint, due to forcing the glue out of the joint too much without giving it a chance to penetrate the wood. With soft wood, clamps can often be removed in twelve hours, but with hard wood, or large surfaces, it is safer to wait a day or two. Remove the surplus glue which oozes from the joint before it becomes thoroughly hard, but not until after it has set, unless necessary. Soft wood glues more readily than hard. Large blocks and pieces glued flatways require more time than edges and thin stuff. If you cannot use clamps for any reason, rub one piece back and forth upon the other a few times, until the glue begins to stick,—an old way to glue edges.

432. **The porosity of the wood must be considered** in determining the thickness of the glue.[1]

433. **To glue end-grain,** first "size" the ends with thin glue, leave to harden, scrape, and then glue in the usual way. The sizing prevents the glue being soaked up too fast by the open pores of the end-wood, but gluing end-grain must be skillfully done to hold.

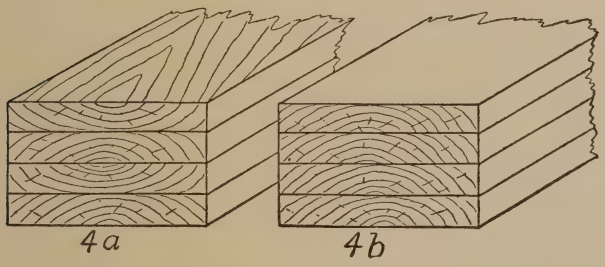
[1] "Hard, close-grained woods, such as maple and birch, do not require as heavy a solution as basswood or poplar, which, while close-grained, are soft and absorbent and will imbibe a lot of glue; nor yet as heavy a solution as oak, which, while hard, is very porous and will absorb a large quantity also." *Bezeau.*

When you have to glue together pieces requiring different thicknesses of glue, you can use thick glue and roughen the surface of the part requiring thin glue; or, in some cases, you can use thin glue and size the part requiring thick glue.



434. **The water in the glue swells the wood near the joint.** Wait for this water to evaporate before planing the surface. If you plane before the wet wood has shrunk back to its original shape, there will be a sunken place at the joint when the water has dried out.

435. **To prevent glue sticking to any part,** rub wax, paraffine, soap, or tallow on that part. Sometimes paper is placed between parts to prevent their sticking together.



436. **Gluing plain-sawed boards together.** "If the glue is of a good quality, that is, as strong as the wood, it is better that the rings should curve in opposite directions, as in Fig. 4a, for then one piece tends to keep the other straight. If, however, the glue is of a poor quality or improperly applied, the joints are less apt to open if the pieces are glued together with the rings curving in the same direction, as in Fig. 4b."—*Forest Products Laboratory*, KOEHLER.

Summary. Essentials for good gluing with hot glue. Cleanliness. Seasoned wood, all the pieces to have similar characteristics, and to have been kept for some time in a warm, dry atmosphere. Warm room, free from drafts, warm wood. Tightly fitting surfaces. Have clamps fitted and ready. Use best grade of glue in clean glue pot. Melt only what you will use at one time (in one day). Keep temperature

of glue down to the melting point (about 140° to 150°). Work quickly. Clamp surfaces tightly together until glue is hard. Do not disturb for a day or two.

437. **Liquid glue,** often called cold glue, is convenient and easy to use, but is not considered so reliable as hot glue. It does very well for much common work, and is better than hot glue used under unfavorable conditions. Cold glue sets slowly, so you do not have to hurry. In fact it is common to wait a little while after applying the glue before putting the parts together. For the same reason, keep the parts clamped together a good deal longer than with hot glue. You cannot hold small pieces in place with the hand, for it would take too long. Under damp, cold conditions cold glue may not harden for several days. Cold glue can be thinned with vinegar or acetic acid, or pour out what you wish to use at once and thin with water.

438. **Water-resistant glues** are made from blood albumin and from casein which is obtained from milk. These have been successfully used for airplanes, etc. Casein glue sets quickly. In tests at the Forest Products Laboratory casein glue joints in spruce were as strong as the wood in four hours and in hard maple in six hours. A short period of clamping is sufficient. As the subject is studied more the use of casein glue is likely to increase. You are advised to get some and experiment with it, following the directions of the makers.

439. **Building-up articles** with a number of smaller pieces by the use of glue has been practised in various forms since the time of the Egyptians at least. As wood becomes scarcer more things are being built up, many from waste scraps. For many purposes, as pattern-making, gluing up with selected pieces prevents warping, change of dimensions, and checking (cracking), which often result from using a large solid block. While a well-made glue joint is usually stronger than the wood at the time it is made, exposure to moist atmosphere, and alternations from moist to dry conditions, are likely, sooner or

later, to weaken joints made with any glue now in use; therefore it is not safe to assume that glue will hold permanently. Much glued work comes apart from putting the parts together without regard to the way wood swells and shrinks, warps and winds, from heat and cold, dampness and dryness.

Reference: *Modern Glues and Glue-Handling.* TEESDALE *and* BEZEAU.

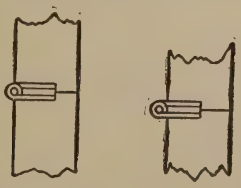
440. Glue pot. This should have an inner and outer vessel like a kitchen double-boiler, the outer vessel containing water. Steam-heated and electric glue pots are in common use, but water in the outer vessel is a sure safeguard against burning the glue.

GROOVING

441. Grooving is best done by machine (**609,** etc.). To cut grooves by hand use a grooving plane (the plow), or the groove can be marked with a knife, the sides cut with saw or chisel, and the wood between pared away with the chisel (**83,** etc.). A piece of wood can be clamped beside the line as a guide (**463–4, 86**). The router can be used (**134,** footnote). A groove cut across the grain is called a dado (**463**), and can be cut with a dado plane.

HINGE-FITTING

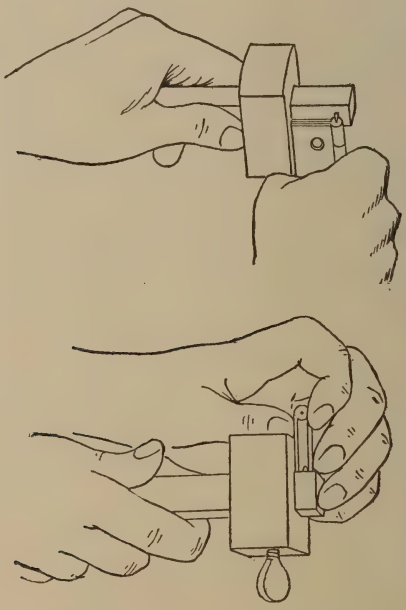
442. Hinge-fitting. There are many kinds of hinges,—butt, strap, T, chest, table, double-action screen, invisible, etc.



Door hinges have either riveted pins or loose pins. See *Door-hinging* (**382**). Common hinges may be as wide as the

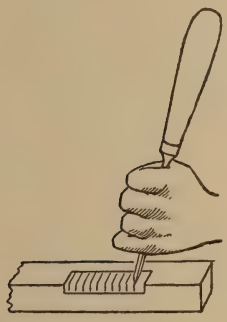
thickness of the wood or less, but for doors and chests they should cover not less than two-thirds of the thickness of the wood.

In the case of a box, for example, place the lid in position (shut), and mark with a knife from each hinge, on both box and cover at the same time, the points for the recesses for the hinges,—usually, for a good-sized box, about twice the length of the hinge from each end. Remove the lid, and with knife or square and gauge mark on box and lid the recesses into which the hinge is to fit, so that the centre of the pin of the hinge will be in line with the back of the box, or sometimes a little outside, as shown.



443. **Setting gauge.** To set for the width to be cut, place point of the spur at the centre of the pin of the hinge. To set for the depth, close the hinge until the leaves (flaps) are

parallel, and set the spur at the middle of the space. A butt-gauge is made for fitting hinges.

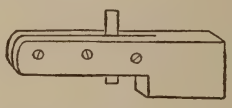


444. Scoring with chisel before paring away the wood. These cross-cuts break up the grain and make it easier to trim to the line, or notches can be cut at the ends and the rest pared away. Bore with brad-awl, drill, or bit, for the screws. Hold the hinges in place with two or three screws in each, and see whether the lid opens and shuts properly. If it does not, it is easier to make alterations before all the screws have been inserted. The position of the hinge can be changed a trifle, as it is screwed in place, by boring the screw holes nearer either edge of the hinge. Strap or surface hinges, T hinges, or the like, are placed so that the centre of the pin is opposite the crack, and then screwed in place.

INLAYING

445. Inlaying. The pieces of thin wood or veneer (580) to be inlaid are cut out, slightly undercut, placed on the surface to be inlaid, marked around, and recesses cut out to fit. The edges are slightly beveled. The recess, which should not be quite so deep as the thickness of the inlay, can be cut out with special cutters, chisels, router, blind-nailing tool

(212), carving tools, or even a knife. If curved, the inlays can be sawed with scroll saw or coping saw (125, 127). Chalk can be rubbed over the surface before marking, to make the outline for the recesses distinct. In cutting the angles, keep them sharp by cutting away from them, not toward them. Parallel lines can often be marked and cut with a double gauge. Such gauges should have a knife-edged spur or cutter with the vertical side toward the line. To glue the inlay in place, hot glue should be used, the inlay pressed hard into place, and clamped or rubbed with the head of a hammer. It is best to use a caul (a form made to fit the surface), and clamp securely, if possible. After the glue has hardened and dried out, trim the surface even with plane, and sand with block. A great variety of bands for inlaying, made of different kinds of wood, can be bought ready to set into grooves. Apply glue, press one end of the band into the groove, and set the rest into place by pressing it in with the hammer head, which you can push along the length of the band. If possible, cover with paper and keep pressed with caul and clamp.



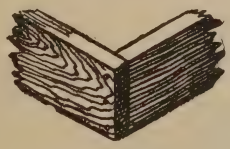
446. A cutter or scratch stock can easily be made, similar to a bead cutter (156).

If both pieces are thin and can be sawed, place the piece to be inlaid on top, and saw both together. The saw-table should be very slightly tilted; or, if a hand jig-saw be used, it should be tipped outward at the top, so that the upper piece will fit tightly in the opening made in the lower one, thus avoiding the loose fitting which would result if the saw were held vertically. Much inlaying is easily done in this way with veneer or very thin stock, the inlaid piece being first glued in place, and then the whole glued upon the surface of the work (see *Veneering*, 580).

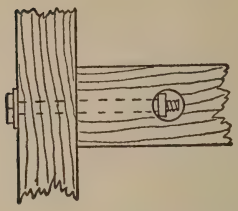
JOINTS

447. Joints, Splices, etc. Making good joints is a matter of *accuracy*,—accurate laying out and accurate cutting. Good joints are an essential part of good work. When you acquire skill enough to make accurate, neat, and strong joints, you will find little trouble with the rest of your work. Plan joints and splices so as to reduce the strength as little as possible. The joint best for one strain is often not the best for another. Many of the joints shown are included for reference, for making by machine, and to give an understanding of the principles. Most of these joints are now made by machinery when possible.

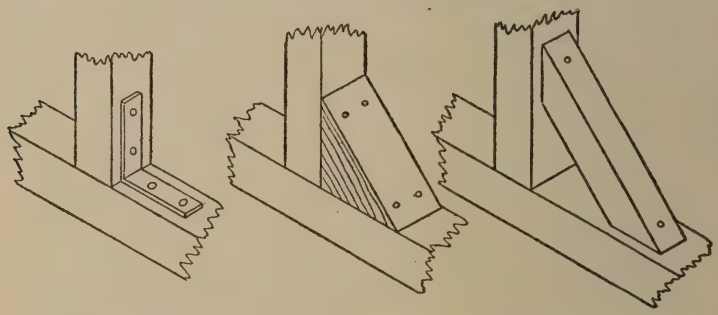
For most good work the stock should be got out of the right thickness and width, and be squared, and in some cases smoothed, before laying out and cutting joints; but there are some exceptions to this rule, as you will discover. Test joints by eye and with square or other tools to see that the angles are right, as already shown. Often this means testing in two directions. Also, in many cases the flat sides or surfaces must be tested. For example, not only must the corners of a picture frame be square and the joints good, but the frame as a whole must be flat and not winding. The posts and studding of a building must not only be square with the sills, but the whole side of the building must be vertical, and in line lengthways.



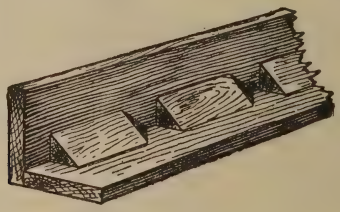
448. Butt joint. Used for a great variety of common work, as boxes, etc. Usually nailed. Screws can be used in such cases as boxes, but do not hold strongly in end-grain (**224**). Butt joints for timbers are usually fastened by "toeing" the nails, that is, slanting them as shown (**215**).



449. Butt joint with draw-bolt. Used for benches, frames for machines, and heavy work which must be held tightly together. The hole shown allows the nut to be put on and tightened. This hole can be plugged afterwards with wood (**177, 186, 569**), if desired. A short section of pipe inserted to fit the hole gives the nut a stronger bearing. A draw-bolt and blind mortise (**467**) are often combined.

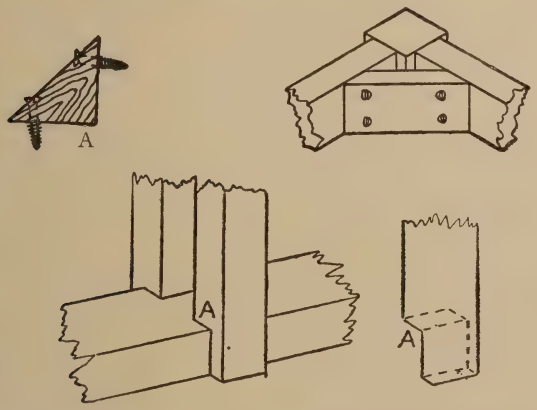


450. A butt joint can be strengthened or stiffened by a corner-iron, by a wooden corner-block, nailed or screwed or

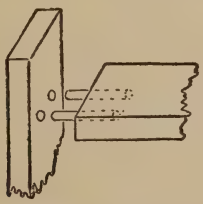


glued, or by a brace. *Corner-blocks* are much used in furniture and cabinet work. Apply hot glue, rub into place, press

for a moment, and leave until secure. These add much to the strength. Larger corner-blocks, angle-blocks, brackets,

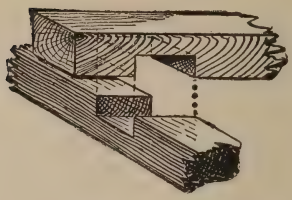


etc., should have the grain run as shown (A), lengthways of the long edge. Metal corner-irons and braces are useful. A shoulder (A) sometimes strengthens against pressure from more than one direction. For butt joints for a packing crate, etc., see **342.**

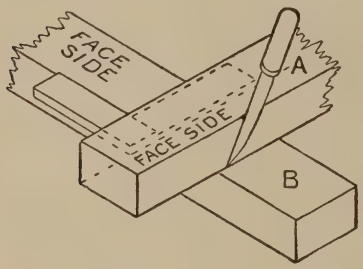


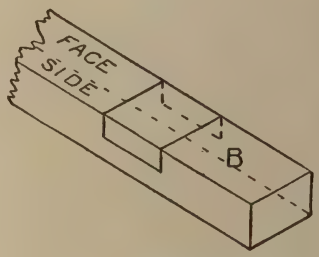
451. Doweled butt joint. The dowels can be wedged (**507**).

452. Housed joint used for timber work and also for smaller constructions. Prevents movement sideways.

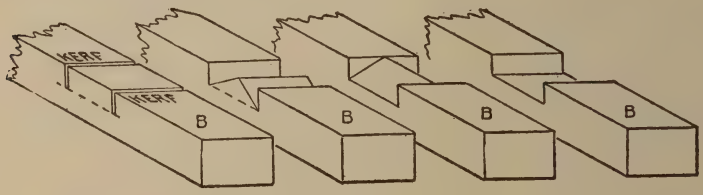


453. Cross-lap or halved joint. Used where two pieces cross. For good work, plane and square the edges before laying out the joint.

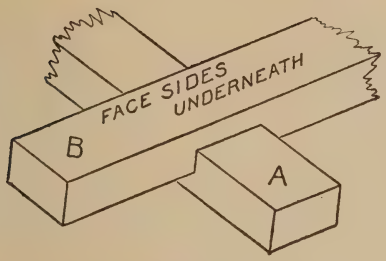




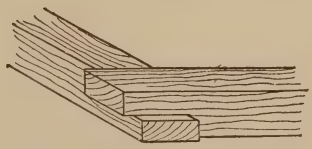
454. Then place the pieces in position and mark the width of the upper one on the lower one with a knife, using the square to get the right angle. Square lines down both edges of the lower piece (B), and mark the depth of the cut (one-half the thickness) on both edges with the gauge. Use gauge from face side (top side) only.



455. Saw down to these gauge-marks, keeping just inside the cross lines (**108**). Pare gradually from each side down to the gauge lines with the chisel. Then cut the middle, until even with the edges. See *Chisel* (**83,** etc.).

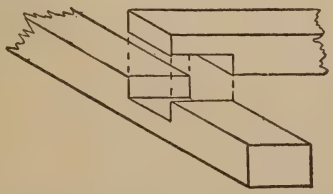


456. Fitting second piece (A). Put the pieces together, turn them over and mark the second piece (A) like the first. Gauge from the face-side. Cut as before and put the two pieces together. Both parts can also be laid out and cut independently.

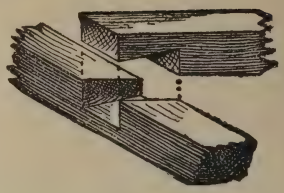


457. End halved-joint. Often used for the sills of buildings and also for small framework. Can be cut entirely with the saw, or with saw and chisel. Both sides can be cut at once from the same piece by machine (circular saw) with a special cutter.

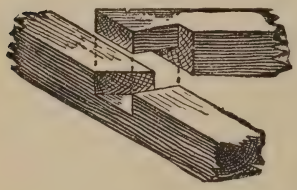
Sometimes the ends are laid out to project, and are cut off after the joint is made. Compare **539.**

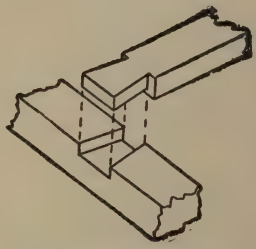


458. Middle halved joint. The end piece can be cut entirely with saw, or with saw and chisel, and the recess with saw and chisel. Sometimes the end is laid out to project and be cut off after the joint is made.

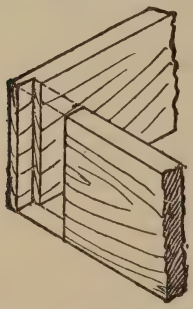


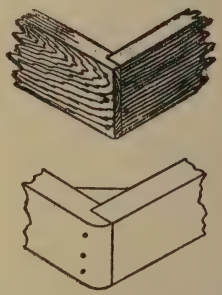
459. Showing end-lap and middle-lap joints beveled. Hard to pull apart.





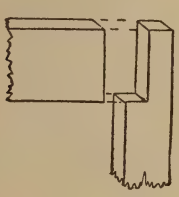
460. Dovetailed middle-lap joints. Will not pull apart. Useful for a cross member in framework. First cut an end half-lap, on one piece as already shown (**457**). Then lay out the dove-tail on this half-lap. Saw the beveled lines first and then the shoulders (**120**). For small work use the back saw. Place this dovetailed end in position on the other piece and mark the part to be removed. It can be laid out with the bevel also. Remove the wood with saw and chisel.

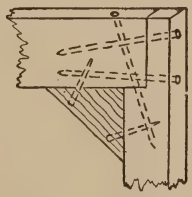




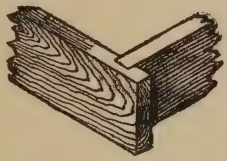
461. Rabbeted joint. Good for box corners and similar work. Best cut by machine. Can be cut with hand saw or

saw and chisel. Conceals part of the end grain. The angle can be rounded and also strengthened with a corner-block (450). See *Rabbeting* (567), *Box-making* (323), *Drawer-making* (383).

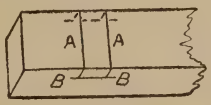




462. Simple joint for corners of screens or other small work. Mark with square and cut with saw, or saw and chisel. Toe the nails as shown. For screens, doors, and similar work add a corner-block with grain running as shown, for strength. A corner-iron can be used.

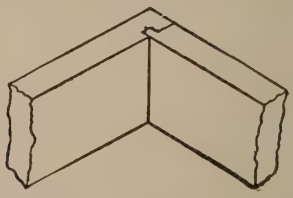


463. Dado. A groove cut across the grain of one piece into which the end of another piece fits. Used for the best work, where the inside angle of the joint shows, and for drawers, steps of step-ladders, shelves, etc. It is best cut by machine (609). A dado plane can be used. See *Coping* (517), *Grooving*, (441), *Rabbeting* (567).

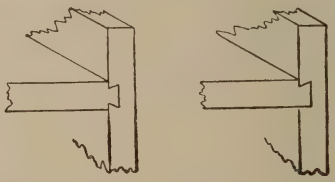


464. To cut a dado with common hand tools, mark it out with square and gauge. Saw just inside of the lines A to the gauge lines B, and remove the wood with the chisel. If necessary, trim the edges with the chisel until the other piece fits (86). The sides of the dado can also be laid out by placing

the parts in position and marking with a knife. Test bottom of dado, if cut by hand, with a trysquare. The depth can be approximately tested with a scrap of wood into which nails or screws have been driven until they project the distance for the depth of the dado. In nice work a dado can be *very slightly* deepened in the middle, to ensure tight fitting at the ends.[1]



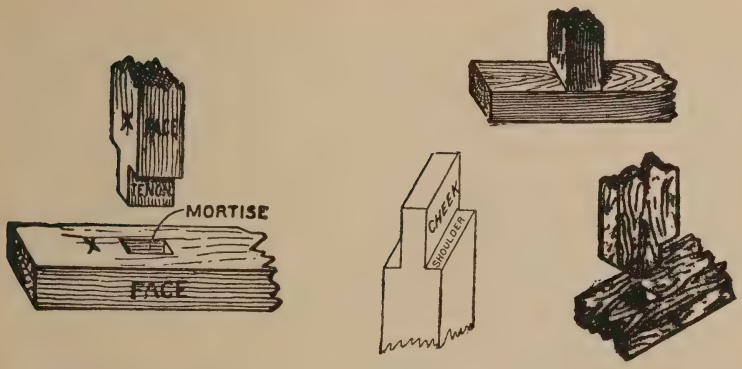
465. Dado and rabbet combined. A good joint for boxes, drawers, tanks, etc. Can be nailed and glued. See *Box-making* (323), *Drawer-making* (383).



466. A dovetailed dado, slipped in from the edge, is stronger than the plain dado, but is harder to make. There is a plane for this purpose.

467. Mortise and Tenon. Mortising. A strong joint. The mortise is the rectangular hole in one piece. The tenon is the projection at the end of the other piece, shaped to fit the mortise. If mortise and tenon go through the wood, it makes a *through* mortise. If they do not go through, it is a *blind* mortise. The former is the stronger, and is used for doors,

[1] A strip of wood can be clamped on the line for the side of the dado, as a gauge or guide for the saw. A strip is sometimes clamped to the saw itself as a gauge for the depth. Saws are made with depth-gauges. Such expedients, though useful under some conditions, are hardly the most workmanlike methods.

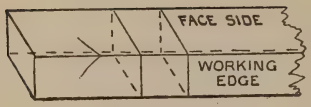


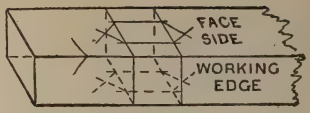
sashes, heavy framework, etc., where great strength is required. In laying out mortises on different sides of a piece, as a chair leg, for example, it is stronger not to have them come opposite or very near one another (**71**).[1] Both mortise and tenon are best cut by machine (**714, 716, 616**).

[1] There is no absolute rule as to the width and length of a mortise and tenon in proportion to the width of the pieces. It is a matter of judgment and experience, and depends on the kind of work, the strain to be put upon the joint, the kind of wood, etc. One-third of the width of the pieces is as thin as a tenon is often made, and a *little* more thickness is often better, particularly if the joint is to be wrenched.

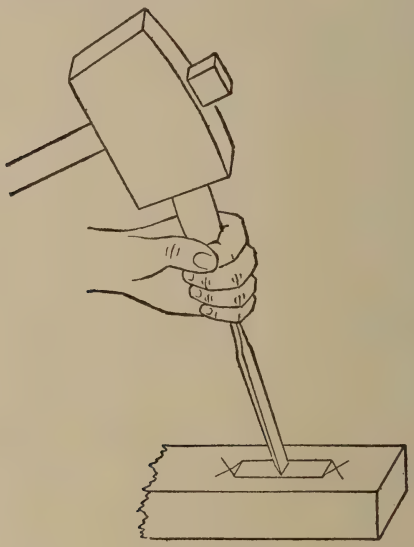
Badly proportioned mortises. In the first case, the tenon is very thin and much weaker than the sides of the mortise. In the second, the tenon is very thick and the sides of the mortise thin and weak. In the third, the mortise is too long, as well as too wide, and is weak. Tenon one-third of

width. If the tenon is merely to hold the piece in place, this is thick enough, as in case of a post resting on a sill, for a wider mortise would weaken the sill too much, but in many cases a little greater thickness may be better. Six times as long as it is wide is about as long as it is well to make a mortise, usually, though there may be exceptions. For stock $^{7}/_{8}''$ thick, $^{3}/_{8}''$ is a common width for a mortise.



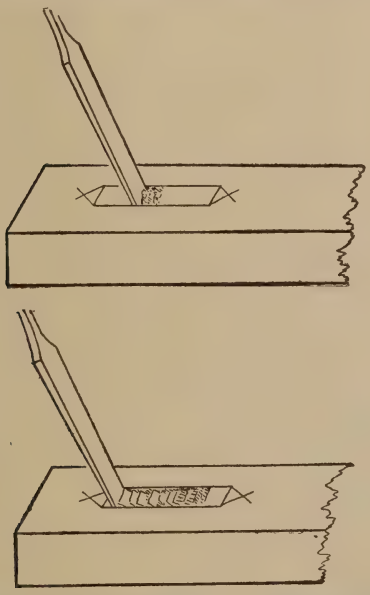


468. To lay out the mortise. First see that the stock is properly squared up (**296**). Select and mark a working-face or face-side, and working-edge or side. From this face and side, or edge, square lines around the piece, the same distance apart as the width of the tenon-piece. With the gauge, mark the place for the mortise on both sides, gauging from the working edge or side. The gauge marks must be the same distance apart as the width of the tenon. In case of a blind mortise, mark on the working-face only.

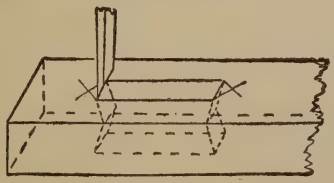


469. Beginning to cut the mortise. Fasten the piece securely. The part to be cut is usually shown by cross marks at the ends, called "witness-marks." Take a chisel nearly the width of the mortise. The firmer chisel will do for light work, but for heavy work use a framing or mortising chisel. Place

it near the middle of the place marked out for the mortise, with the basil turned outward, and make a cut. Reverse the tool and cut the other way, so as to make a V-shaped hole. Keep making cuts toward each end. At the end of each stroke pull the chisel handle toward the middle to loosen the chips. Cut about half-way through until you reach the ends. Then turn the piece over and repeat the process until you cut through.

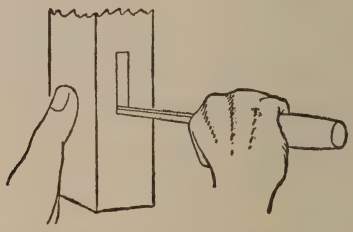


470. Showing the V-shaped cut made by the chisel, and also the cutting continued to the ends.

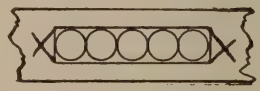


471. Trimming to the line at the ends, after cutting through from both sides. Keep the flat side of the chisel out-

ward or toward the end of the mortise. Finally trim the sides of the mortise.

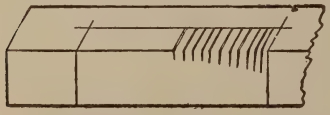


472. Testing accuracy of the cutting. The square can be used, except for very small mortises.

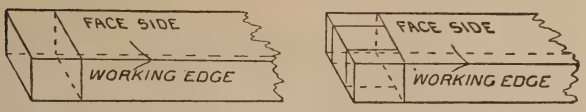


473. Another way to cut a mortise. Bore holes to remove most of the wood with a bit a little narrower than the width of the mortise (**504**). Finish by paring with chisel. Avoid driving the chisel lengthways of the grain until the mortise is well cleared out or you may split the wood. In many cases one hole can be bored and the mortise sawed carefully, just within the lines, with the jig saw, and finally trimmed to the exact line with the chisel.[1]

[1] *Other methods.* Place chisel upright at end of mortise, flat side outward. Make a cut. Pare to this cut as shown. Make another vertical cut, pare again, and so on. Do the same at the other end, and on the opposite side. Finally trim out the middle.



Take chisel the width of the mortise. Begin near the middle. Place the chisel as shown and make successive cuts, increasing in depth to



474. To lay out the tenon. Select and mark the working-face and edge on the tenon-piece. From these faces square a line around the piece at the proper distance from the end. If the tenon is to go through the mortise-piece, this distance will be the thickness of the mortise-piece, but allow a trifle more for the tenon to protrude and be trimmed off afterward. With the gauge set as for the mortise, gauge lines for the tenon on both sides. Gauge from the working face. Connect these lines on the end. By laying out mortise and tenon at the same time, the gauge can be used for both without re-setting.[1]

475. To cut the tenon. Saw carefully on the lines *lm* and *rs*, and then *gh* and its opposite. Trim with chisel to fit the mortise if necessary. In soft wood the sides of the tenon can sometimes be cut best with the chisel. Cut a little

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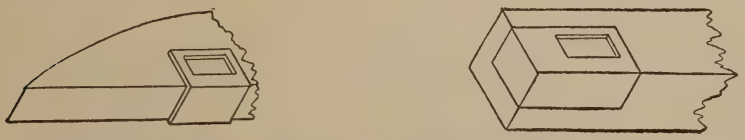
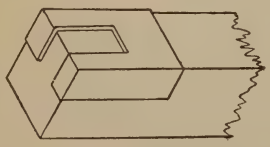
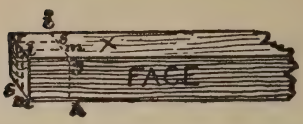
the end. Then back to the other end. Turn over and repeat. Finally trim to line.



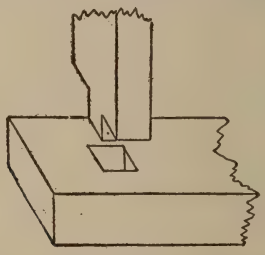
A pattern or templet, for laying out mortises, can be made of metal or even tough paper or cardboard, but it does not pay to make templets for only a few mortises.



[1] A pattern or templet, for laying out tenons, can be made of metal or tough cardboard. Unnecessary if machinery can be used. A jig can easily be contrived to guide the saw when many tenons are to be cut by hand, but it does not pay, usually, to make templets or jigs for a small number of tenons, while a large number should be cut by machine.



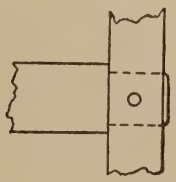
chamfer around the end. This can be trimmed off later. The tenon should fit snugly but not drive hard, lest it split out the sides of the mortise. For nice work the shoulders of a tenon may be very slightly undercut (490) to make a tight joint.



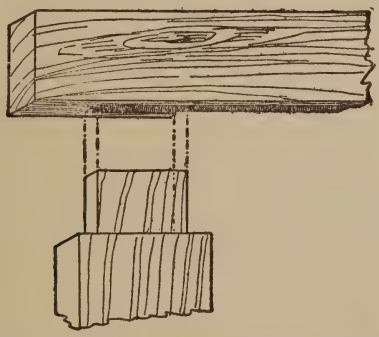
476. **Stub mortise and tenon,** where the surfaces of the pieces are to be flush. Keeps the tenon piece from moving sideways. As this tenon is usually quite short, the mortise is marked and cut on one side only. Used in framing construction and for fine work also.

477. **Very commonly the wood is cut away on three or on four sides** as shown, (479, 480), to form the tenon, either for a through joint or a blind one. The laying out and cutting are on the same principle as for the joints already shown. Unless the mortise comes near the end of the wood, the shoulders at the edges are usually quite narrow, but should be wide enough to cover the mortise in case of shrinkage of the tenon-piece—from $1/8''$ to $3/4''$, according to the size of the stock. Saw lengthways first, then cut shoulders, otherwise you will cut

away some of your marks. Also, it is best to cut with the grain first (120).[1] One shoulder of a tenon is sometimes set back farther than the other, as when there is a moulding on the inner edge, in case of some doors, panels, etc.



478. **A through tenon is sometimes carried beyond the mortise,** and the end slightly chamfered.

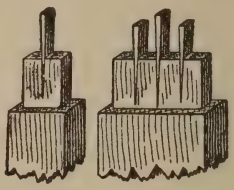


479. **When the mortise comes near the end of the piece,** as shown, in the case of a door, for instance, make the piece in

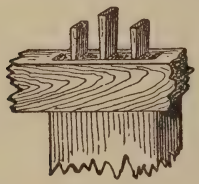
[1] When there is objection to the end of a through tenon showing, it can be cut a little short and the mortise plugged with wood. Have the grain of the plug run to match that of the surface, make the plug a very little too large, bevel the edges slightly, glue, drive tightly into place, and smooth off when dry.

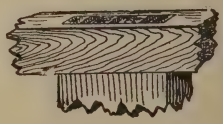
which the mortise is cut a little too long, and cut off the projecting end (lug) after the work is finally put together. This lessens the danger of splitting the wood and helps in taking the joint apart while you are fitting it.

480. **Tenons are often wedged, for strength.** First enlarge the outer side of the mortise to make it tapering, as shown.



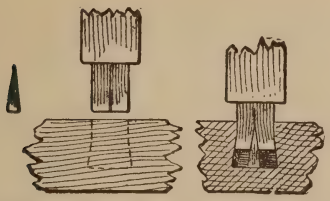
481. **Next make one or more saw kerfs in the end of the tenon** and cut slender wedges to fit. A small tenon can be split carefully with a chisel. Insert tenon in mortise and drive the wedges into the kerfs. For indoor work, dip the wedges in glue and put glue in the kerfs with a thin stick.



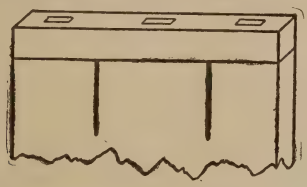


482. **Drive the tenon home,** spreading the end like a dovetail, and trim off the projecting end.

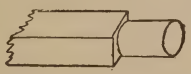
483. **Wedged blind mortise.** Made on the principle just shown, but the size and taper of the wedges must be so planned that when they are driven home they will spread the tenon to fit the mortise. If the wedges are too long, they will prevent the joint closing. The bottom of the mortise must be flat where the wedges will bear or they may be bent to one side.



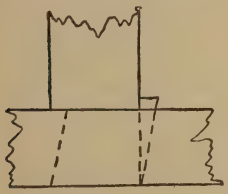
Apply glue (for indoor work), start the wedges in the cracks, and drive the tenon into place. A very strong joint if well made.

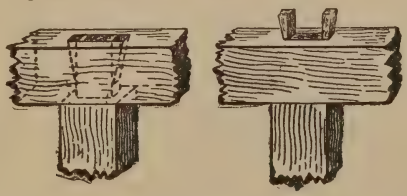


484. Splitting from expansion and contraction. When a wide piece is to be mortised into another piece, two or more tenons are sometimes cut, to avoid too long a mortise, but this will not do for very wide stock, unless some of the tenons are fitted loosely, for the expansion and contraction of the wide piece may cause it to buckle or split (**747**).



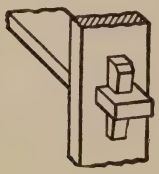
485. Round tenon, fitting into a round hole. A common construction, used for stool and chair legs and rungs, for wheels, sleds, etc. Round tenons can be wedged (**507**). This differs from doweling only at one end. See **500.**

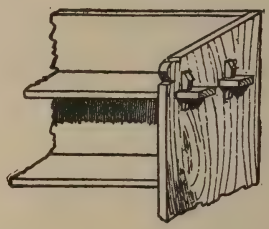




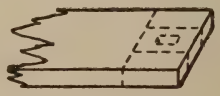
486. Showing (at the left) mortise and tenon dovetailed and fastened with a wedge-shaped key. Also (at the right)

wedging at the ends of mortise. If glue is used this strengthens the joint, but is not so strong as where the tenon itself is spread into a dovetail.

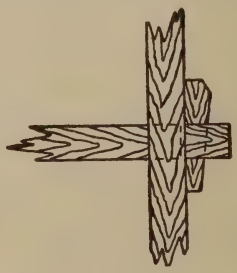




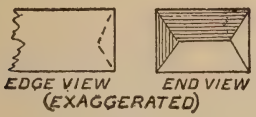
487. **Keyed mortise and tenon.** The tenon projects beyond the mortise, and is fastened with a wedge-shaped key which fits into another mortise cut in the tenon. In this case, shoulders are usually cut on only two sides of the main tenon, as shown. A strong joint if well proportioned. Much used for tables, book-cases, benches, etc., and for various "knock-down" constructions (**2**, illustration).



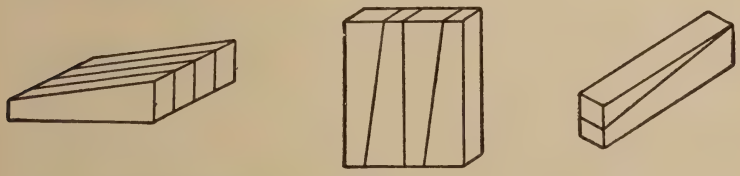
488. **Gauge lines on the tenon** for the sides of the mortise into which the key or wedge is to fit, and square lines across.



489. **Cut the mortise a little too long** (a little beyond the line) at the inner end, so that the key will force the joint to a tight fit. A round pin is sometimes used.

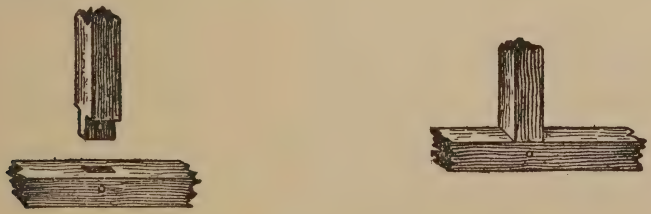


490. **The shoulders (467) of the tenons** can be very slightly undercut, or beveled inward, from each side and edge, to ensure a snug fit.



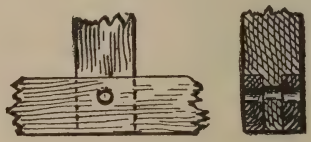
491. **Plain wedge-shaped keys** can be got out by making a tapering block and then sawing lengthways, or by making a rectangular block and sawing slantingly, or by making each wedge separately.

492. **Half-lap and mortise combined.** Used quite often. A strong joint if braces are added.

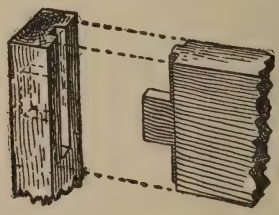


493. **Pinning a mortised joint.** A strong wooden pin is driven through a hole to fasten the joint. Done both for small

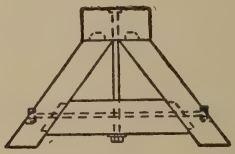
work and in large construction. The large pins used for heavy work are called treenails. In any case, the pins should be split out with the grain (rift) so that they will be straight-grained, for strength (**742**). When the tenon is thick, and when it goes only partly through, it is common to fasten it with a wooden pin. If the wood be thin, wedges are often used.



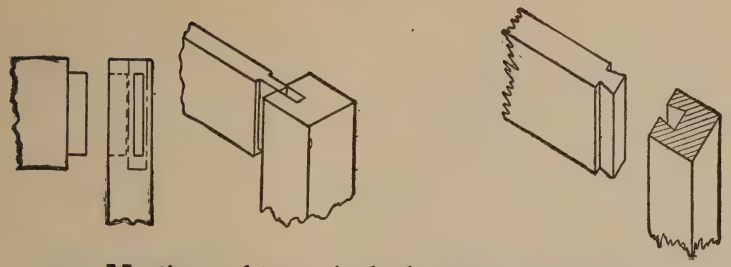
494. Draw-boring. To make a snug fit at the joint the hole in the tenon is bored a very little nearer the shoulder than the holes in the mortise piece. This requires good judgment, for if the holes are much out of line, there will be too great strain on the end of the tenon, on the pin, and on the sides of the mortise. Used for heavy construction, framing, etc.



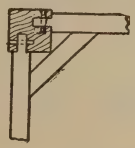
495. Tongue and groove combined with tenon. Good for door frames and similar cases.



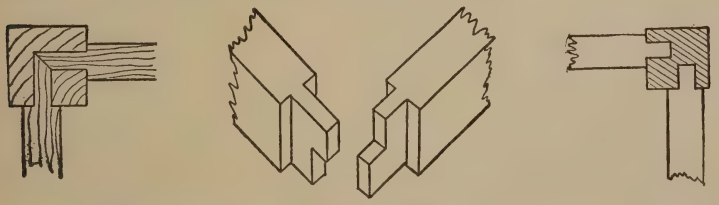
496. Mortise joints for horses for heavy work, held together by bolts.



497. Mortise and tenon is the best joint for framing tables, chairs, etc. Doweling (**500**) is not so strong, usually, though sometimes it is better, particularly for very light work. Mortise joints of this kind can be pinned (**493**). Such mortises are sometimes dovetailed, as shown at the right. See also **487.**



498. These joints like many others, are greatly strengthened by gluing and screwing corner blocks or braces on the inside. Metal ones can be bought.

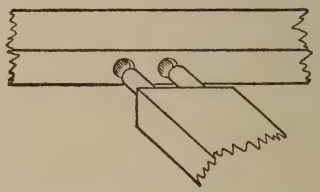


499. When the legs of a table or chair are small, the mortises and tenons will run into each other. In that case mitre the ends of the tenons, or let one-half of each tenon extend the depth of the mortise. Either of these ways is doubtless stronger than the joint shown at the right, but the latter is easier to make and a trifle cheaper.

500. Doweling. A doweled joint is held together by round wooden pins, called dowels, driven, and usually glued,

into each of the pieces. The mortise and tenon (467) is a stronger joint, as a rule.[1] The hardest part of doweling by hand is to bore the holes in line. Doweling is valuable in pattern-making and where the parts are to be made separable

by gluing the dowel into one part only. With skilful work, particularly when the dowels are split and wedged, doweling can be made strong enough for a great many purposes; but if poorly done, as in much ready-made furniture, it is an unreliable joint. Boring for dowels is best done by machine (669) or with a doweling jig (504).

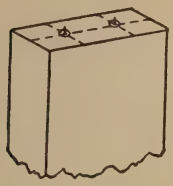


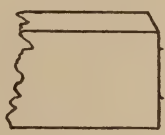
501. **Showing dowels driven, and glued,** into one piece, ready to be forced, after gluing, into the holes in the other piece. The holes are countersunk slightly to catch the surplus glue.

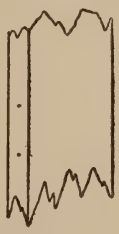
502. **To dowel with common hand tools,** square lines across both pieces from the working faces, and gauge lines at the required distance from the joint edge of each piece, crossing the lines just squared. Prick a small hole at each point

[1] The comparative effectiveness of doweling and mortising has long been a matter of dispute. It seems probable, as a general rule, other things being equal, that a mortise and tenon joint is stronger than a doweled one. But there are many cases in which doweling is better. Also, doweling is often used where mortising would be better. Tests made at the Forest Products Laboratory showed that through mortised and tenoned doors had the greatest strength, and stiffness. Blind mortised ones had the least strength, but slightly greater stiffness than doweled doors.

marked, to start the worm of the bit at the exact spot. A line squared on the surface, in the line of the centre of the hole, may



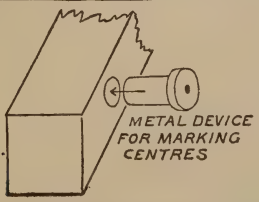




help in boring straight. At the right is shown an old way to mark positions for dowels. Drive brads with sharpened heads into one piece. Press the two pieces together and the brads will prick corresponding points in the other piece.[1]

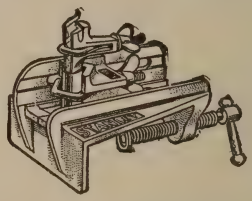
DOWEL SHARPENER

503. Trim off the sharp edge at the ends. The dowels must be thoroughly seasoned and must be a snug fit. Fit the work together before gluing, then take apart and glue the dowels into one of the pieces only. Wipe off surplus glue and do not disturb for a day or two. Then clean off any hardened glue and glue into the other piece, also gluing the joint between the parts. Clamp the joint together and leave under pressure until dry. If dowels are made to fit very tightly, are baked a

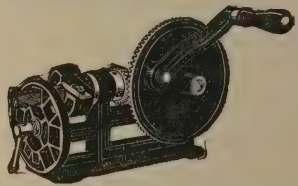


[1] When there are many duplicate pieces to be doweled, a template of metal with holes punched can be used.

while before using, and then glued and driven at once, they will swell to fit very firmly. For $^7/_8''$ stock a $^3/_8''$ dowel is usually about the right size. $^1/_4''$ can sometimes be used. 2″ is usually far enough for a $^3/_8''$ dowel to extend into $^7/_8''$ stock. For thicker stock use larger dowels. Cut dowels a little short to be sure that the surfaces of the wood will come together.



504. Doweling jig for boring squarely. Has a depth gauge. Will take stock up to 3″ thick. Can be used also as a bit-guide for mortising (**473**). Will take bits up to ¾″.



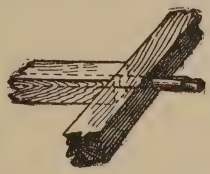
505. Dowels hold best if grooved or toothed lengthways, and are sometimes grooved spirally. A dowel cutter is a simple and useful machine for making dowels of different sizes.[1]

506. Doweled edge-joint. The joint and dowels are glued. See **532**.

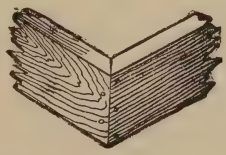
507. A wedged dowel. The dowel is first split (or sawed) lengthways at the end, and a wedge with a long taper fitted.

[1] Dowel-plate or "sizer." A steel plate with holes of such sizes that pins made by driving strips of wood through them will drive snugly into holes made by the corresponding bits. Useful when you cannot buy dowels.

Then enlarge the bottom of the hole correspondingly (for which an inside gouge (**93**) is best), glue dowel and wedge in the



split or saw-kerf, and force the joint home. A through dowel as shown is simple, but a blind one requires careful calculation for the same reason as in mortising. If the wedge be too long or too thick, the joint cannot be driven home.

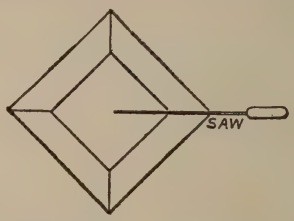


508. Mitring. The mitre is not a strong joint, but is frequently used for appearance. It shows no end-grain. It is best cut by Circular saw (**585**), with a Mitre-box (**128**), a Trimmer (**159**), or a Sander (**664**).

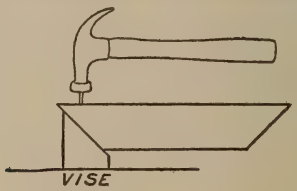
509. Common result of mitring wide pieces flatways. If the wood shrinks, it is likely to open a tapering crack from the inner corner; if it expands, from the outer corner.

510. To cut a mitre with common hand tools, lay out the angle (45°) with the bevel (**35, 36**), and saw to the line. The beginner can rarely saw four mitres by hand, as for a picture

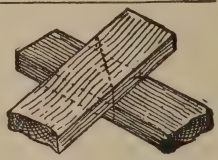
frame, without having to trim one or more to fit. Sawing to fit can be done by drawing the pieces together as tightly as



you can and sawing down through in the line of the joint which does not fit, as shown. If one sawing is not enough, repeat. See **535.** Also, one or both ends can be planed or pared with the chisel.[1] The mitre is a common joint for mouldings, etc. See *Coping* (**517**) and *Splaying* (**538**). To make a rectangular mitred frame, the mitres must be correct and the opposite pieces must be of the same length. Sometimes one piece can be placed on the opposite one and both sawed together.



511. To nail a mitred joint, fasten one piece upright in the vise. Bore a hole in the other piece slightly smaller than the nail, and drive the nail until it pricks through. Then place this piece on the first, with the corner slightly projecting.

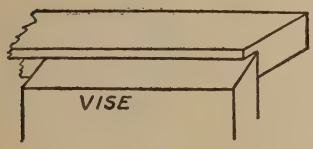


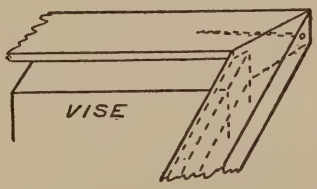
[1] Sometimes a mitre can be laid out by placing one piece upon the other, testing the angle, and marking the points of crossing. Lines connecting these points will give the angle.

When the nail is driven home the corners will meet.[1] If the joint is also to be glued, size first with thin glue and when dry, scrape, glue, and nail as shown.[2] Mitre joints can also be doweled.

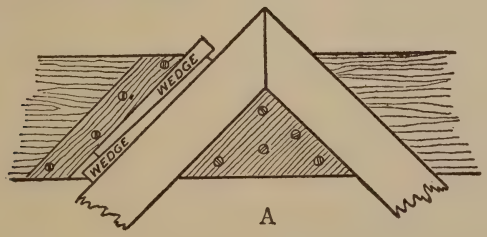
512. Corner-block for mitred joint. The grain should run as shown. Corrugated fasteners can often be used for the back of a picture frame or for work like screens, etc.

513. Clamping mitred corner. The clamps bear on blocks fastened on temporarily. Suitable only for work which has not been finished. Mitre clamped by wedges is shown at the



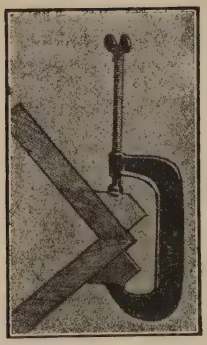


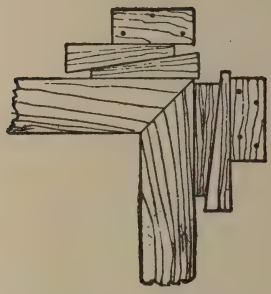
[1] Another way to nail a mitre.



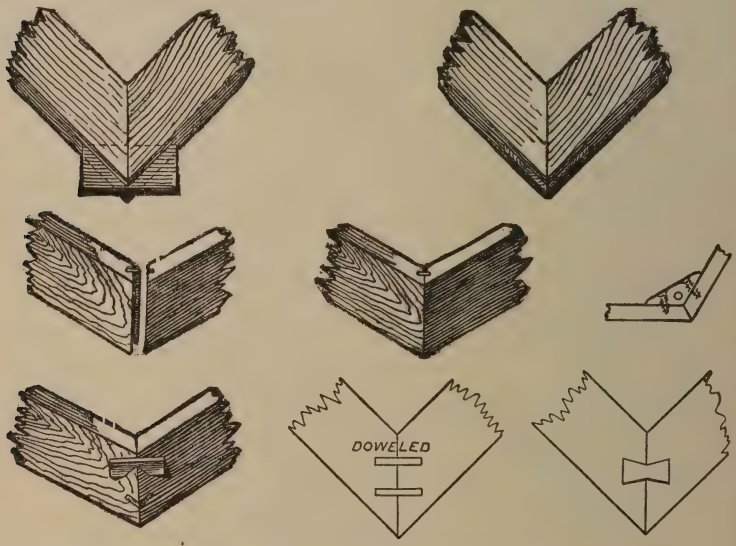
Form for holding mitred joint. The piece A, of hard wood, should have the grain run as shown, to prevent change of angle from shrinkage.

[2] This applies only to indoor work. Do not use common glue for joints to be exposed to the weather.



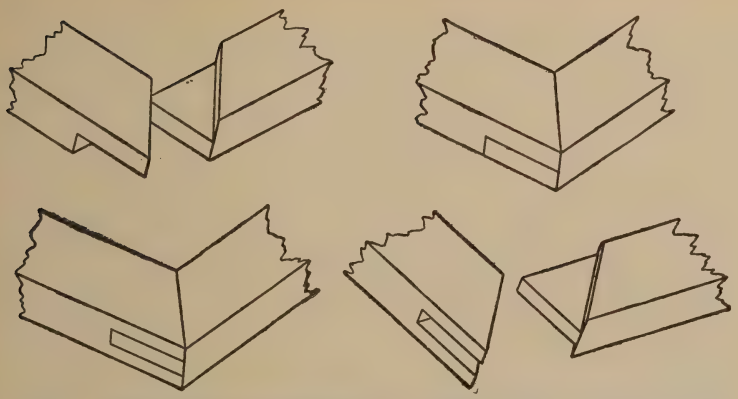


right. The joint is laid flat, blocks nailed near it, and wedges driven.[1] See also **228, 241.**

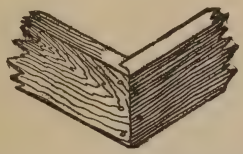


514. Ways of strengthening a mitred joint.

[1] Special mitre cutters and clamping devices are made for picture frames, but the skilled workman usually fastens mitres by hand. Some forms hold the joint so that both pieces can be sawed with one cut, that is, sawed to fit (**510**). See *mitre-box* (**128**), *trimmer* (**159**), *sander* (**664**).



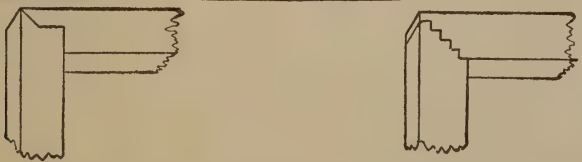
515. Other forms showing a mitred face combined with halved joint, etc.



516. Combination of mitre and rabbet. Shows no end-grain and is stronger than a simple mitre, but harder to make by hand. Quickly made by machine.[1]

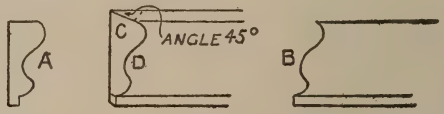
517. Coping. The end of a moulding is "coped" when it is cut to fit another piece. Coping and Dadoing (**463**) are the best ways to fit inside corners in first-class work.

518. Instead of mitring (508) the ends of both pieces when they meet, cut the end of one square, and fit the other to it. For example, suppose the moulding to have the shape shown



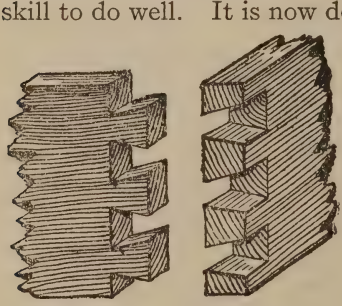
[1] Joints which can be nailed both ways and glued. (See *circular saw* 585). Special cutters can be obtained for such joints.

in section view A. Cut the end of one piece square. Then mitre the end of the other piece as shown at C. Then cut the



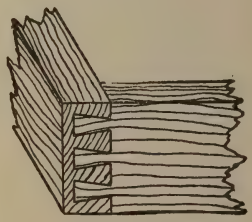
end of the moulding squarely to the curved line D, formed by cutting the mitre, with coping saw (127) or other tool. This will give the end the shape shown at B. If this end B is now pushed against the first piece A, it will fit it. The joint can be slightly undercut to make a tight fit. If a mitre opens or draws apart the defect is conspicuous. This is less likely to be the case with coping. In case of long mouldings or strips, cut one very slightly too long, and spring into place.

519. **Dovetailing.** An excellent joint, scientific and workmanlike. It holds the parts in place without nails or screws, but glue is used for cabinet work. Dovetailing requires much skill to do well. It is now done by machine.



TAILS PINS

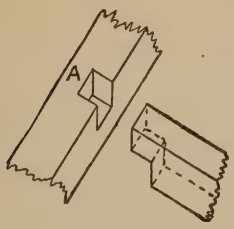
DOVETAILED JOINT FOR A BOX



LAP OR DRAWER DOVETAILING

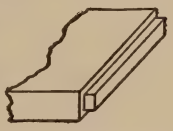
520. **Make the pins first,** mark the tails from them, and then cut the tails. In laying out dovetailing, put the face-side on the inside, the joint-edge at the bottom.[1]

[1] The common form, used in joining the sides of a box can be done as follows: mark the lines *ab*, using the gauge, completely around each piece, at a distance from the end equal to the thickness of the stock. Lay off the lines *cd* on the end of the piece *A*. Lay off the oblique lines *ec* on both



521. Gained joint. Used for framing construction and for small work also. The recess A is called a gain. A dado (463) goes entirely across the surface. A gain does not.

522. Gained joint for shelves. The gain does not show at the front edge. The shoulders (467) at the sides of the shelves are sometimes omitted.



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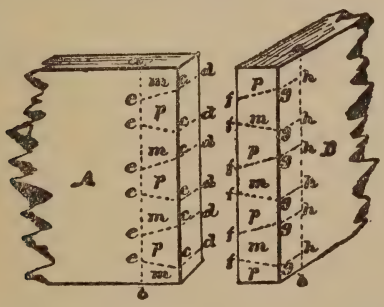
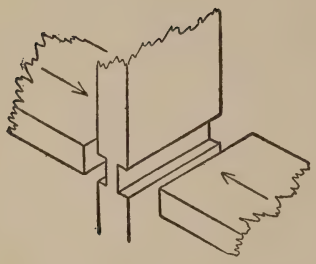
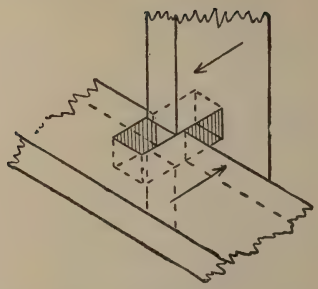
sides of the wood. Fasten the piece in the vise, end upward, and with the back-saw (or a dovetail-saw) cut by these oblique lines (*ec*) to the lines *ab*. Lay the piece flat, and with the chisel cut out the parts to be removed (marked *m*), as in cutting a mortise, undercutting very slightly at the end.



When this cutting has been cleanly done, lay the piece *A* on the end of the piece *B* in the way it is finally to go, so that the pins just cut will rest exactly in position across the end of the piece *B*. Mark around the pins, forming the oblique lines *fg*, from the ends of which square the lines *gh* on both sides of the piece. Remove the wood as before, taking care not to cut on the wrong sides of the lines which mark the pins, or the dovetailing may fit too loosely. When fitted, apply glue, put together, and when dry smooth off.

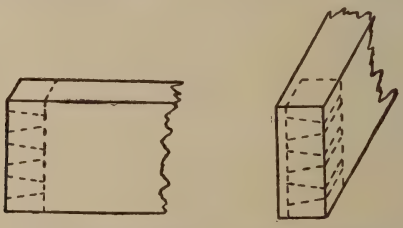




523. Joint for pigeon-holes and other divisions. The dadoes (**463**) can be made all the way across either the vertical or the horizontal piece. Sometimes they are made one-half in the vertical and one-half in the horizontal piece, on the half-lap principle (**453**). Done best by machinery. A dovetailed joint can be used for very nice work, but is hard to make.

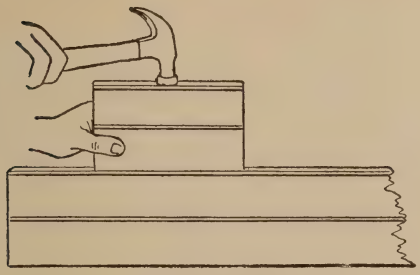
524. Edge-joints. To join two or more boards or planks to form a wider surface. The simplest way, for rough work, is to square or "joint" the edges and fasten the pieces together with cleats on the side (**366**). Edge-joints are best made by machine (**585, 654,** etc.)

Lap or *drawer dovetailing* is similar to the preceding form, but the dovetailing does not go through to the front. The side piece A is marked and cut as just shown, the pins being shorter; then the other piece B is marked

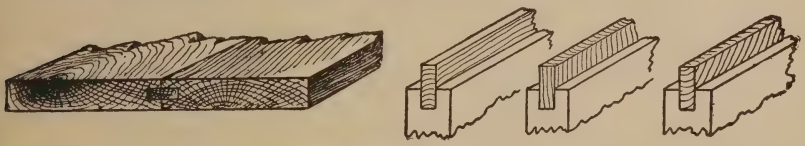


and cut to fit. *Mitre dovetailing* (*blind* or *secret dovetailing*) is used where it is desired to conceal the dovetails, the result looking like an ordinary mitred joint. This process requires much skill and care.

Practised workmen in dovetailing usually (unless exact symmetry of the pins is required) determine the bevels for the pins of the first piece by eye.



525. Matched boards or sheathing, tongued and grooved. Put together without glue, usually. Used for inside and outside finish, sheathing, etc. A bead or moulding at one edge makes the joint less conspicuous, particularly when it opens from shrinkage of the wood. When necessary to strike the edge, use a piece of waste sheathing. See **421**.



526. Splined joint. Edges grooved (**441**) and a spline (a strip cut to fit) inserted, with or without glue, according to the kind of work. Used for heavy construction, mill flooring, etc., and sometimes for small work. Best done by machine, but can be made with matching-planes. The tongues or splines can be made with the grain running lengthways, crossways, or diagonally as shown above. Crossways and diagonally are strongest.

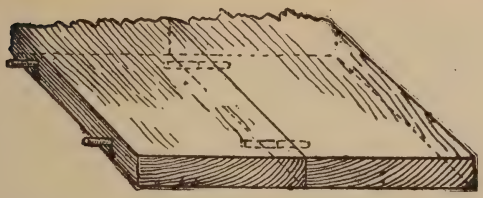
527. Matched joints to make a tight fit. Done by machine with special cutters. **Dovetailed joints.** If glued, the parts can be separated only by breaking the wood. Best done by machine, although there is a hand plane for the purpose.

528. **Rabbeted joint,** sometimes used instead of tongued and grooved joint for rough boarding, flooring, etc. Best done by machine, but can be made with rabbet-plane.

529. **Fillestered joint.** Both edges rabbeted and a fillet (strip cut to fit) used to fill the rabbets. Best done by circular saw (**612**) and other machines, but can be made with rabbet plane.

530. **Shiplap.** Used like clapboards for siding. See **362.**

531. **Methods of forming a wide surface,** as for the back of a bookcase, etc. See **381.**



532. Doweled edge-joint, usually glued, unless meant to be separable, as in some patterns for castings, tops of extension dining-tables, etc., when the dowels are glued into one part only. See **500.**

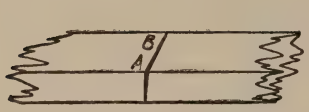
533. "Glue-joints."[1] A common and very important joint. The edges are "jointed" to make a tight joint, and then glued together. For this process, see **146.** Best made by machine. Splines (**526**) or dowels (**532**) are often used with glue-joints. Quarter-sawed or radial-sawed middle boards are best.

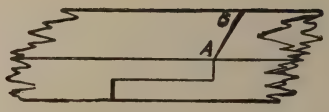
534. Wide surface built up of selected pieces, glued, doweled, bolted, etc. The grain of the wood is reversed, as shown at the ends, in adjoining pieces to counteract the tendency to warp, etc.[2] See **146, 426,** etc. Tops of benches, machine-tables, etc., are often made in this way.

535. End-joints. Saw the ends off as squarely as possible and plane or pare them if necessary. *To saw to a fit,* hold the pieces in position and run the saw down through the joint AB. If one sawing is not sufficient, repeat the operation. This

[1] Any joint in which glue is used is a glue-joint of course, but the term is often applied especially to those cases in which edges are joined to form a wider or thicker surface, as the joints of a table-top.

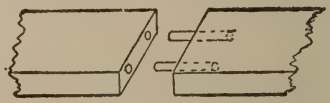
[2] This may result in a slightly undulating surface, so when the surface must be flat and is to be fastened so that it cannot warp, arrange the grain to run the same way in all the pieces. Rift stock or quarter-sawed (**739**) will give the nearest to a flat surface.



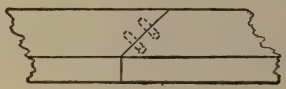


method can be used with pieces which meet at any angle, but should not be relied on as a regular way to make joints, lest it result in a careless method of work.

536. Ends butted over a support. Toeing the nails draws the ends tightly together. The ends are sometimes undercut slightly, so that the joint is a little open at the bottom, as shown, to make it close tightly on the side which shows.



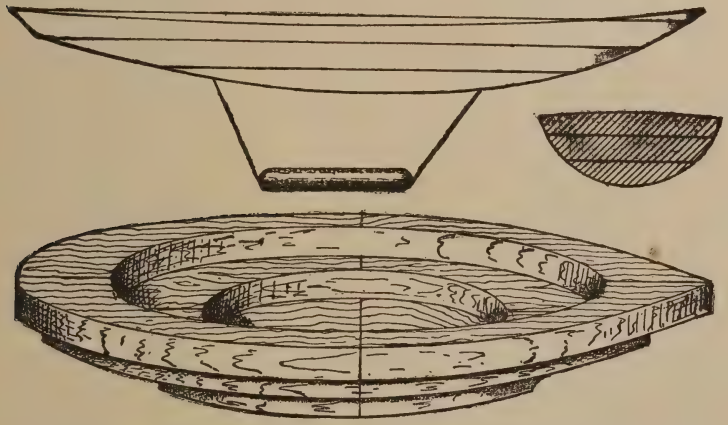
537. Doweled end-joint. The dowel can be split and wedged (**507**).



538. Ends scarfed or splayed and fastened by slightly slanting the nails. Often used for mouldings, clapboards, etc. If this joint draws apart it is not so conspicuous as when a butt joint opens. The ends are sometimes grooved, splined (**526**), doweled, as shown, etc., if the stock is thick enough.

539. Slip joint, sometimes called slip mortise and tenon, and sometimes incorrectly called a dovetail. A common joint for light framework like screens, etc. Can be glued, nailed, screwed, or pinned. Best made by machine. To make by hand, see **457**. Also at the right, multiple slip joint or lock-

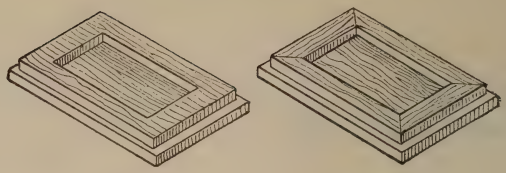
corner made by machine. A good joint for light boxes, can be glued and pinned with a metal pin.



540. Broad-surface Joints. Showing built-up hull of model boat. The surfaces must be flat and true, and fit exactly. They are best prepared by machine. A great many solid forms are made in this way,—shoe lasts, air-plane propellers, etc.[1]

SAP SIDES JOINED HEART SIDES JOINED

[1] The frames of machines, chopping-blocks, masts, bows, fishing-rods, and many other objects are often built up of selected pieces, to avoid flaws and defects, to arrange the grain to the best advantage, and to counteract



RIGHT WRONG

541. Edge of table top built up to make it thicker. Shown bottom side up. Have the grain of the parts to be glued to the top run the same way as that of the top itself. Otherwise expansion or contraction of the top may cause splitting or open joints,—unless the facing be screwed on through slotted holes and without glue.

FRONT BACK GLUED

542. When gluing two or more thin boards to make a thicker piece, if one of the pieces be turned slightly out of line with the grain of the wood, it will lessen the danger of warping. See *Plywood* (758).

543. Splicing. There are many ways of splicing two or more pieces to get greater length, some for bridge-building, house-framing, etc., being quite complicated, but rarely used by the general woodworker.

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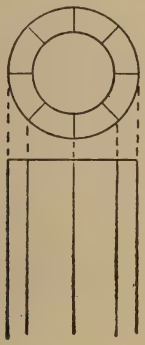
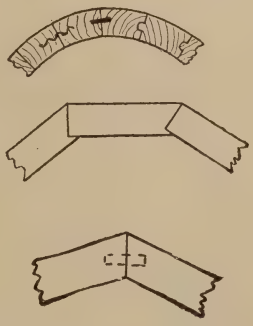
warping tendencies. When glue is used there is always danger that the joints may open and the work come apart, unless also screwed, nailed or bolted. A piece that is practically perfect will be more durable than a built-up combination, under all conditions, but may not hold its shape so well or be so strong at first as one built up with smaller pieces of selected stock.

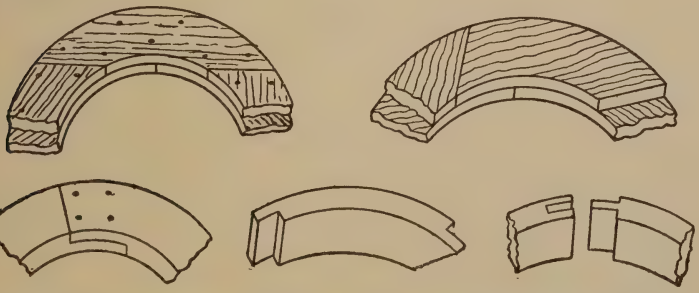
HALVED SPLICE

544. Spliced butt joint. Strips (fish plates) nailed on each side. Used for scaffolding and other rough work. The nails or bolts are "staggered" (213).



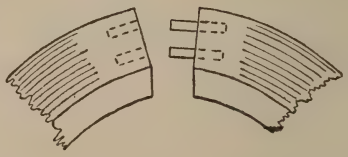


545. Columns, cylinders, silos, and other curved forms are often built up with strips—lags or staves,—the edges being beveled in various ways, sometimes tongued and grooved, splined, or doweled. Such joints are best fitted by machine. Sometimes the last stave is fitted by hand. See *Clamps* (238).

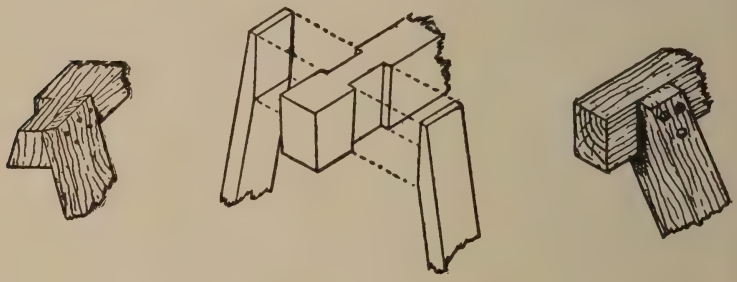


546. Other circular or curved constructions often have to be built up, as shown, or in similar ways. The grain is arranged

in different directions, and the pieces break joints so that they strengthen each other when fastened together. Even large

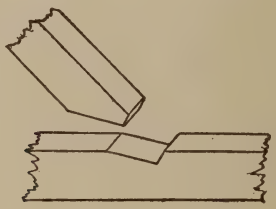


circular houses have been built up of layers of plank in this way. Doweling is sometimes used. See also *Bending* (312).

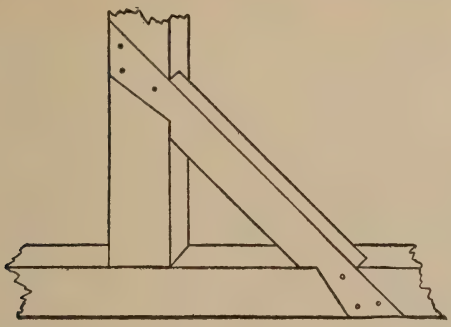


547. Some common joints for horses and in similar cases.

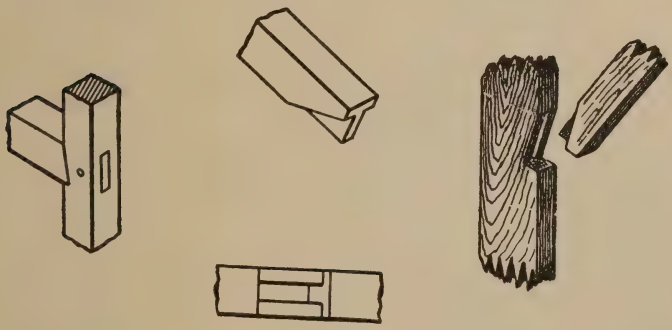
548. Joint for a brace. The mitred joint, to be nailed, shown in 450, is sufficient for common work and light building construction. Where there is much strain to be put upon the work, use one of the joints shown below.



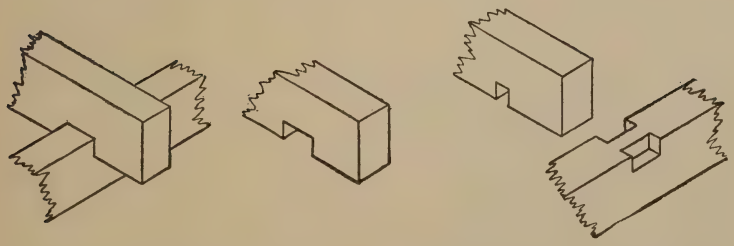
549. Thrust joint for a brace. Stronger than a nailed mitre.



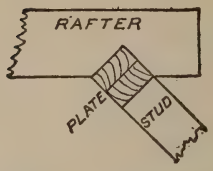
550. Another form for diagonal bracing.



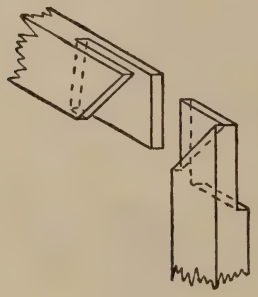
551. Joints for heavy construction.

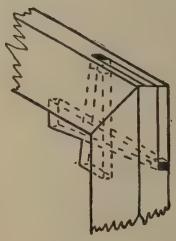


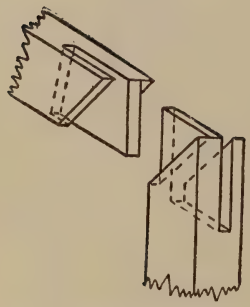
552. Notched joint, used in timber construction and sometimes for small work. **Cogged joint.**

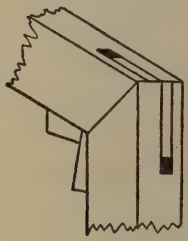


553. Bird's mouth joint, used for rafters. There are many other joints used in building construction.



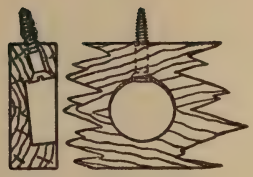


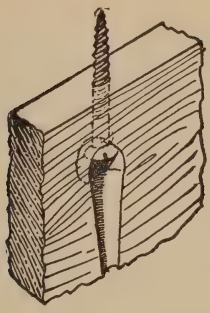




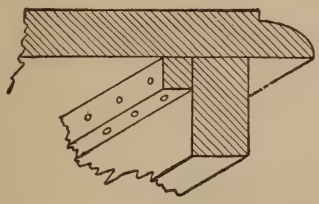
554. Stretcher joint. Used for frames for canvas for painters' use, for stretching lace curtains, etc. By tapping the wedges or keys at the corners the frame is enlarged and the canvas or other material stretched. Two arrangements are shown.

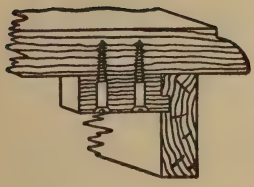
555. Screw-pockets for fastening the top of a table to the rails beneath, and for similar cases. First bore a good-sized hole on the inside of the rail, then bore the hole for the screw

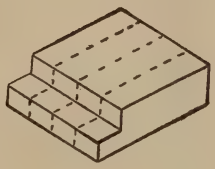




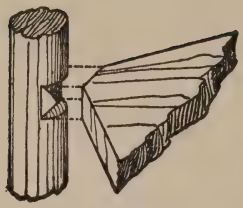
down from the top edge of the rail at a slight slant into the larger hole first bored. The screws are driven up from the inside, where they will not show.



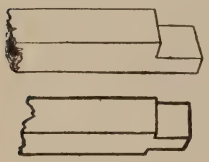


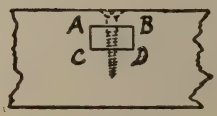


556. Other methods. Strips of wood with holes can be screwed to the rails and also to the top. For wide tops slotted holes will allow for expansion and contraction of the top (**747**). Wooden buttons grooved into the rails and screwed to the top, as shown, are also used. To make these get out a wide piece as shown, and then saw into narrow pieces. Common corner-irons can be used and there are special metal devices. See *Counterboring* (**177**).

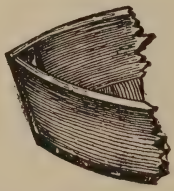


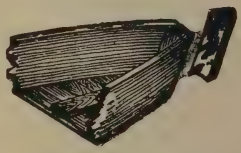
557. Joint for fastening shelf to a round leg. Can be glued; or a dowel can be used.



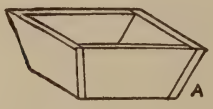


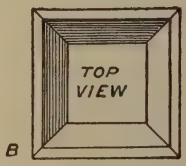
558. Showing tenon for cross bars of a sled and in similar cases. Also corner-iron for cross bar of a sled, and screw put through runner and tenon where cross bar is mortised into runner.





559. Rabbeted joint for boat stem. Also other joints for bow of boat.





560. Hopper joint. Easily made by machine, but hard to make by hand. For plain butt joints as shown at A, lay out slant for the sides with the bevel, or by measuring from a

centre line. Saw the joints and nail together. For a mitred joint, as at B, the simplest way for the beginner is to saw the edges squarely as for butt joints, and then bevel them with the plane. See *Circular saw* (**622**).

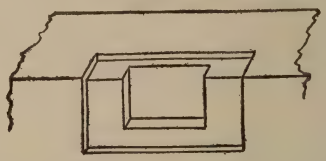
LOCK-FITTING

561. Lock-fitting. There are so many varieties of locks,—rim-locks, locks to be screwed on the outside of the wood, others to be sunk in recesses cut in the side of the wood, mortise-locks to be let into mortises, chest-locks, door-locks, padlocks, cupboard-locks, drawer-locks, etc., that it will be wise to examine a well-fitted lock like the one you have to fit.

562. To fit a chest or box-lock (not a mortise-lock), place it in position. Determine the place for the keyhole, and bore it. Mark around the part to be sunk in the wood, and cut it out with gouge and chisel. Trim the keyhole to a neat outline like the shape of the key. When the lock has been screwed in place, put the "hasp," or part to be fastened to the lid, into its place in the lock, where it will be when the chest is closed. Then shut the lid, and press slightly to make a mark to help show where to put the hasp, or transfer-paper can be put between the hasp and the wood, or blackened grease rubbed on the plate of the hasp. Sometimes the hasp has points to prick the wood. Outline the place for it with knife, square, and gauge, sink the plate into the lid flush with the surface, and screw it in place. A mortise-lock is fitted in a similar way, but let into a mortise.

563. To fit a common drawer-lock, determine the place for the keyhole and bore it. Hold the lock in position on the inside and with a pencil mark the outline of the box-part of the lock, which bears against the wood, and cut the recess for it. Put the lock into place and mark the outline of the outer plate on the inside of the drawer front and on the top edge. The thickness of the metal must be allowed for, both on the inside

and on the edge, that the surface of the plate may be flush with the wood. Pare away the wood carefully with the chisel to let the plate sink flush. When the keyhole is shaped, see whether



the lock works before screwing it on. Close the drawer and turn the key hard to raise the bolt (the top of which has been previously rubbed with blackened grease, such as can be scraped from an oilstone), which will mark the place for the mortise into which it is to slide. Cut this mortise and the drawer can be locked.

564. Rim-lock for door. Hold in position. The keyhole for a common house door is usually about 2′ 11″ from the floor, unless it conflicts with a mortise. Mark places for holes, cut the holes, and screw lock in place. Add knob-plates, knobs, and escutcheons, and set the striking-plate on the jamb.

565. Mortise door lock. Cut mortise in edge of door to fit body of lock (**469,** etc.), and sink face plate of lock flush with edge of door. Remove lock, place on outside of door, mark places for holes for knob and key, cut holes, screw lock in place, put on knob-plates, knobs, and escutcheons. Then mark place for striking plate on jamb and set it flush with the wood.

Mitring, see **508.**

Mortising, see **467.**

Painting, see **412.**

Paneling, see **372.**

PATTERN MAKING

566. Pattern making. A distinct and important branch of woodworking, calling for a high degree of skill and technical

knowledge. It is not treated here for lack of space, and because it is not considered as coming within the scope of the beginner or the amateur general woodworker. When the beginner reaches the point where he wishes to make patterns for castings, he should seek a competent instructor or some of the numerous books on the subject.

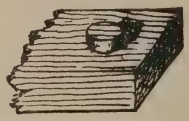
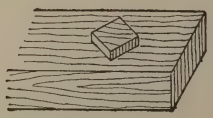
RABBETING

567. Rabbeting. A rabbet is a rectangular recess cut along the edge of a piece of material. Best made by machine (**612**). To make by hand, use a rabbet plane. If you have no such plane, mark out the rabbet carefully with gauge or square and knife. In some cases a rabbet can be sawed. The chisel can be used to remove the wood. For the final trimming, hold flat side of chisel toward the line (**86**). A strip of wood or the blade of a square can be clamped at the line, as a guide for the cutting (wood for sawing, the square for chiselling). Rabbets are best cut with the Jointer (**654**), with special cutters on the Circular saw bench, or as shown in **612**.

REPAIRING FURNITURE, ETC.

568. Repairing often requires more knowledge and skill than to make new articles. When using glue for furniture which has come apart, first remove all the old glue, and see that the parts fit tightly, otherwise there is little use in re-gluing. If a tenon be too small, glue on thin pieces and trim them afterwards to fit. If this cannot be done, wrap a little muslin laid in glue, around the tenon. This can be done with dowels. Sometimes tenons and dowels can be split and wedged (**507**). Where the heads of screws would show, first make, with bit or chisel, a round or square hole to admit the head of the screw and deep enough to plug with a piece of wood of the same kind. (See **569**.) A mended joint may not be so

strong as when new, therefore reinforce it with a block, or brace, glued and screwed on the under, inner, or back side, when it will not show. Corner-irons or iron straps are often best. Always press re-glued parts firmly together until the glue has dried out, with hand-screws (see **244** for suggestion), clamps, a rope doubled and twisted with a stick,—any means to apply pressure (**228, 241,** etc.).[1]

569. A large hole or defect is best filled with a plug of wood. Trim the hole to an irregular shape, make the plug a trifle too large, and bevel it slightly, so that when driven in place or clamped, with glue, it will make a snug fit. Match wood and grain as closely as you can. When the glue is hard, trim to the surface. To make circular plugs cut into the side of a piece of wood, making a short dowel, with the grain cross-ways, and then split off the plugs with a saw or chisel. See **177, 186.**

ROUNDING STICKS AND EDGES

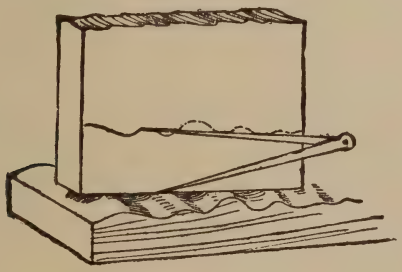
570. Rounding sticks and edges by hand. First, make the stick square, then eight-sided (**155.** See also **618**). Set the plane fine, plane off the eight corners, making the stick sixteen-sided. Do the rest of the rounding with fine strokes. Use the file for small sticks, turning the stick as you file. Finish by sanding (**201**). Round an edge by first planing away the two angles, so that there will be four angles, and so on. The lathe

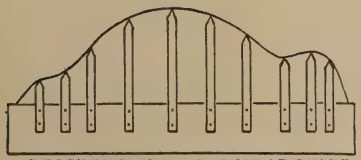
[1] Where the rungs of chairs, etc., cannot be re-glued strongly, a small iron rod can often be inserted under the rung to bolt the parts together. By sinking the head and nut of the rod and plugging the holes, the rod can be quite inconspicuous. Strong adhesive tape is very useful where appearance is not important.

(**672**) is the regular machine for rounding pieces, or the dowel-cutter for small sticks (**505**), and the moulding machine for edges (**719**). When rounding little sticks with the knife, draw the stick along between the knife and your leg. There is a cornering-tool for slightly rounding edges (arrises).

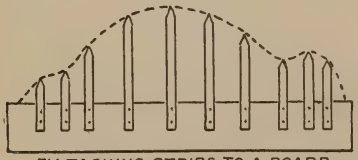
SCRIBING WITH COMPASSES, ETC.

571. Scribing with compasses, etc., to fit an irregular surface. Mark a piece to be fitted to an irregular surface by





REPRODUCING AN IRREGULAR SHAPE



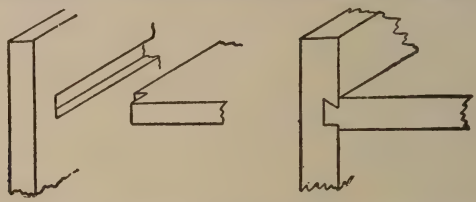
BY TACKING STRIPS TO A BOARD

drawing the compasses along, as shown. Keep them at the same angle. (See also **66** footnote). With small mouldings or where the compasses cannot scribe, make a series of dots with one of the points.[1]

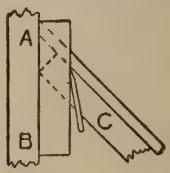
[1] To fit the last of a series of boards in an irregular corner, or in similar cases, mark the required width at each end of the board. Hold the board so that these marks are equally distant from the corner. Set the compasses to reach from either of the marks to the corner, and scribe the length of the board.

SHELF-FITTING

572. **Permanent shelves** are best fitted at the ends with a gained joint (522), a plain grooved joint or dado (463), or a

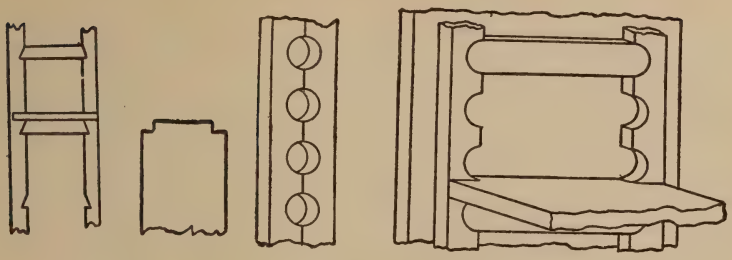


dovetail for very nice work (466). Removable shelves can rest on cleats at the ends, but this is usually not desirable. With expensive wood it is common to use cheaper wood for shelves, with the front edge faced with the more costly wood. After gluing on the facing, planing and smoothing the surfaces, the cheaper wood is stained to match the facing.



To mark the board C to fit the edge AB at the angle A. If the edge AB is straight, fit the bevel to the angle and mark the board by it. If you have no bevel, place a board of uniform width against the edge AB and mark a line parallel to it. Or scribe with compasses (571). If the edge AB is crooked, scribe with compasses.

To find the bevel in a case like fitting the bottom to the sides of a boat, lay a straight-edge across and set the bevel to fit the angle. Sometimes you can scribe parallel to the straight-edge, and sometimes simply plane to fit. See 28, 34, 318.



573. **Showing notched strips** into which fit cleats to support the shelves. Lay the strips on edge side by side, clamp together, and cut notches as if one piece; or cut the notches on the side of a narrow board, and then saw into strips. For another way; a row of holes can be bored in a strip, the strip sawed in two, and cleats with rounded ends used.

Simple moveable metal supports, with pins to fit into holes in the sides of the case, can be obtained; or, for rough work, dowels or screw-eyes can be used.

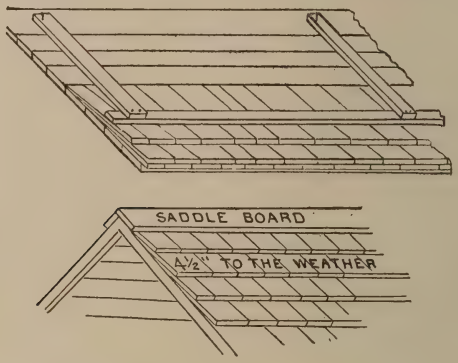
Shellacing, see **406.**

SHINGLING

574. **Shingling.** Begin shingling a roof at the eaves and work upward. Lay a row the length of the roof, letting the butts slightly overhang the edge. On this row lay another, breaking joints with that underneath; that is, lay the first row double, but so that the shingles of the upper row cover the joints of the row beneath. Leave a slight space (perhaps $1/8''$ to $3/8''$) between the shingles, unless they are wet. This gives room for swelling and allows the water to run off freely. Fasten each shingle with two shingle nails (one near each edge, within perhaps $1''$), far enough up from the butt to be covered by the next row of shingles.

575. **Lay the butts of each row** by a chalk-line (**49, 50**) or against the edge of a narrow board, which can be adjusted

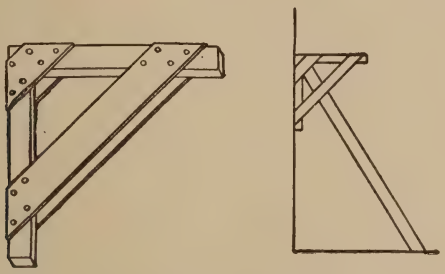
and temporarily held in place by two strips nailed to it and to the ridge of the roof. If you chalk two parallel lines, two courses can be carried along together. Be careful to break joints with the row last laid, and with the one above it, to prevent leaking.



Common shingles (16″ long) for a roof are best laid 4½″ to the weather; that is, with that portion of the length exposed at the butt. Some lay 5″ to the weather. If shingles of extra length are used, the distance can be varied accordingly. Trim off the upper ends of the top row and put on saddle-boards at the top, nailing one saddle-board to the edge of the other.

576. **Cut nails are better than wire ones** for shingling, as the latter rust away quickly, but galvanized wire nails last much longer. Cedar or cypress shingles are good. Spruce is poor for shingles. Sapwood is objectionable. Small knots or defects at the thin ends, where they will be covered by two or three layers, do no harm in common work. A cheaper grade is often used for the sides of less important buildings, and laid with greater exposure to the weather. Old-fashioned shingles of cypress, cedar, pine, etc., hand-rift (split with the grain, 742) and then shaved to shape, were very durable compared with modern sawed shingles. Manufactured shingles of asbestos, asphalt, etc., have advantages over any but the better grades of wooden shingles, besides being either incombustible

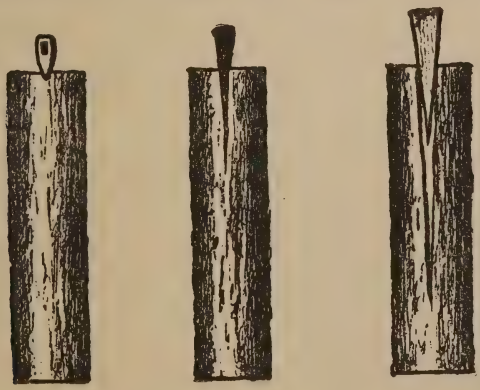
or more or less fire-resistant. Wooden ones may look better in some cases.



577. Showing easily made brackets for supporting staging at the eaves. Brackets for support part way up the roof (roof-brackets) can be bought at any hardware shop.

SPLITTING WOOD

578. Splitting wood is done on the principle of the wedge. Wood will split, as it cracks, most easily on the radial lines



or in the direction of the medullary rays (**731**), and also on the lines of the annual rings (**732**). See **74, 75, 76.**

Staining, see **399.**

UPHOLSTERING

579. Upholstering. This cannot be treated in this book, but the reader is referred to *Furniture Upholstery*, JOHNSON, for a simple treatment of the subject.

Varnishing. See 407.

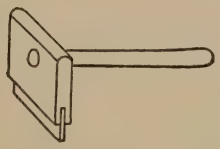
VENEERING

580. Veneering was practised by the ancients. It has become an important part of the manufacture of modern furniture, etc. Veneering on a large scale, as done in factories, is a highly technical process, and hardly suitable work for the beginner; but small plain work can be successfully done if sufficient care be taken. Veneers are sawed or sliced very thin from valuable logs, and are used to cover the surface of cheaper wood.

Veneering should be done upon soft, straight-grained wood which is not liable to warp or twist and is free from knots, as clear pine, chestnut, etc. The base or core must be thoroughly seasoned. Radial-sawed stock is best (739). The core can be built of strips (754). The surface to be veneered and the under side of the veneer are first toothed with the toothing plane (134, footnote). The surface to be veneered is sized with thin glue, which is allowed to dry.

The veneer, which should be cut a little too large, is dampened with hot water on the upper side, and the glue then applied to the other side. Next, the surface to be veneered is glued and the veneer put in place. The whole operation should be done as quickly as possible. To keep the veneer firmly in place until the glue has set strongly, it is pressed and held by a caul or mould previously fitted to the surface and secured by clamps. Veneering pins (brads) can be used to help keep the veneer in place temporarily until the cauls are in place. The caul can be made of wood or of metal, should be warm (thick zinc retains heat well), and the surfaces soaped

to prevent sticking, or paper inserted. When cauls are clamped the pressure should come first near the middle of the surface, so that the glue will be evenly distributed. Leave for several days. For very small flat work or patching, a flat-iron can be used.



581. Veneers are also laid with a veneering hammer. After dampening the surface, and pressing into place with the hand, the hammer is held near the head with the handle turned away from the operator, pressed down hard, and worked over the surface from the centre to the edge, forcing out the glue. The surface is finally dampened and wiped with a dry cloth. The use of the hammer requires considerable skill and experience.

The hammer is worked along in a zigzag way, advancing first one edge and then the other. The blade of the hammer is of thin steel, with rounded edges, set in a kerf in the head. In case of blisters, make a slit with a knife to let the air escape.

QUESTIONS

ASSEMBLING. 1. *Which parts should usually be assembled first? Why?*

2. *What must not be neglected when assembling?*

3. *In what order should you assemble a common box?—a four-legged table?—a mitred picture frame?—a simple framed building of one story?*

4. *Show the process of testing case work.*

5. *Why should glue not be used in attaching table-tops, for fastening panels, and in similar cases?*

BENDING. 6. *Name the essentials for bending wood successfully.*

7. *Describe a steam chest.*

8. *If you have no steam chest, what can you do?*

9. *Show how to arrange forms for bending.*

10. *If only one side of a piece will show after bending, what can sometimes be done?*

11. *What other methods of bending are there?*

12. *When is it best to bend wood in the direction of the medullary rays? —at right angles to them?*

BEVEL AND CHAMFER. 13. *What is the difference between a bevel and a chamfer?*

14. *Show how to lay out a chamfer or a bevel, how to cut it, and how to test it.*

15. *When both side and end are to be cut which would you do first?*

BOX MAKING. 16. *What is most essential in box making?*

17. *Where should nails be used and where screws?*

18. *Where may glue be used and where is it of little value?*

19. *Show good joints for common boxes—for tanks.*

20. *In what ways are packing boxes often weak? Show how to make strong ones.*

21. *In what ways are packing crates often weak? Show how to make strong ones.*

CARVING. 22. *How are most carving tools sharpened?*

23. *Show the process of removing waste wood for simple designs in low relief, how to cut the outline, to mold the shape, and to finish the background.*

24. *Show the principle of roughing out work in high relief.*

25. *How much smoothness should the work have when done?*

26. *What are the most suitable ways to finish carved work?*

CLAPBOARDING. 27. *Show the process of laying clapboards.*

CLEATING. 28. *Show how to arrange cleats, and the nails or screws, most strongly for a door made of several boards.*

29. *Why should glue not be used in such cases?*

30. *When cleating wide stock how can you allow for expansion and contraction?*

31. *Show arrangements for end cleats—for a dovetailed side cleat.*

DOOR AND PANEL MAKING. 32. *What advantages have paneled doors?*

33. *What joints can be used in making doors? Which is best?*

34. *Why must a panel not fit tightly? Why must it not be glued in place?*

35. *Show the general process of putting a door together.*

36. *Compare built-up smooth doors and doors with panels.*

37. *Show the process of fitting and hinging a door.*

DRAWER MAKING. 38. *Show suitable joints for a drawer. Which is the best?*

39. *In which direction should the grain of the bottom run? Why?*

40. *How should the bottom be fitted and fastened? Why?*

41. *Show how to arrange slides and guides for a drawer.*

FINISHING. 42. *What conditions are essential for successful finishing?*

43. *Show how to fill holes and cracks—to remove dents and bruises.*

44. *From what direction should the light come?*

45. *Which parts should you finish first? Why?*

46. *Show the process of finishing doors and paneled work. Why should this order be followed?*

47. *Compare water, oil, and alcohol stains. State their advantages and disadvantages. Which do you prefer?*

48. *Show how to apply stains.*

49. *Why are varnish stains unsuitable for nice work?*

50. *What is the fuming process?*

51. *When and why may you use lime water, bi-chromate of potash, etc.?*

52. *What advantages have these chemical processes?*

53. *When is filling desirable? What solid ingredient is best?*

54. *Show the process.*

55. *Show how to use shellac—how to begin the strokes, how to continue them, and how to rub the work down.*

56. *With what may shellac be thinned?*

57. *What conditions are necessary for good varnishing?*

58. *With what may varnish be thinned?*

59. *How can you avoid "laps" in applying shellac and varnish?*

60. *How much time should be allowed between coats of varnish and of shellac? Why?*

61. *Show the process of finishing doors and paneled work.*

62. *Why should this order be followed?*

63. *Show the process of rubbing down.*

64. *Can you use shellac over varnish?—varnish over shellac? Why?*

65. *What is essential for a good wax finish?*

66. *Show the process of waxing and rubbing.*

67. *How should you give an oil finish?*

68. *Describe the use of wood lacquer?*

69. *Show how to refinish old work—if in bad condition—if merely worn and dull.*

70. *How can you clean and brighten an old finish?*

71. *What methods of finishing are used in factories?*

PAINTING. 72. *What conditions are essential for successful painting?*

73. *How should you treat knots or resinous places before painting?*

74. *Why should the first coat be thin for new work?*

75. *Show the general process of applying paint—how to avoid laps.*

76. *When should you putty holes and cracks?*

77. *How long should paint be allowed to harden between coats? Why?*

78. *Show the process of painting doors and paneled work. Why follow this order?*

79. *With what should paint be thinned for outside work?—for inside work?*

80. *When should you use turpentine to thin for outside work?*

81. *What thinner should be used to produce a flat dull surface for interior work?*

82. *What kinds of paint are used for iron?*

83. *What should be the composition of putty?*

FLASHING. 84. *Show how to flash window and door casings, etc.—a brick chimney—a valley.*

FLOORLAYING. 85. *What should be the condition of the under floor?*

86. *Show how to lay the first boards, how to draw each succeeding board to a tight joint, how to break joints at the ends, and how to nail securely.*

87. *What conditions of temperature and dryness, when laying, are necessary to make a permanently satisfactory floor?*

GLAZING. 88. *Show how to do common glazing on old work—on new work—how to set a plate glass mirror.*

GLUE AND GLUING. 89. *How should you prepare hot glue?*

90. *What are the essential conditions for good gluing?*

91. *Why should the pieces be equally dry and sawed in the same way?*

92. *How must the surfaces be fitted to make a good joint?*

93. *In case of glue joints like those for table-tops, what is the order of procedure in planing and gluing?*

94. *What are the temperature requirements for room, wood, and glue to insure good work?*

95. *How is the strength of glue affected by heating to a higher temperature?*

96. *After applying the glue, what should you do next?*

97. *How much time can you take to do good work with hot glue?*

98. *When can you safely remove clamps from a glued joint?*

99. *How can you often glue small pieces of soft wood?*

100. *If you have no means of clamping, what can you do?*

101. *How thick should the glue be? Why should its thickness depend upon the characteristics of the wood?*

102. *At what stage of the process should water be put with the glue?*

103. *What effect has remelting upon the strength of glue?*

104. *How can you tell good glue?*

105. *How should you glue end-grain? Why size the end-grain?*

106. *How desirable are end butt joints in regard to strength?*

107. *How long should a glued joint be left before planing the surface? Why?*

108. *What are the advantages of liquid glue?—its disadvantages?*

109. *From what causes do glued joints frequently come apart? Can this be prevented?*

110. *What is the proper construction for a glue pot?*

111. *From what are water-resistant glues made?*

112. *Why is stock often built up by gluing? How should the parts be arranged with reference to the heart and sap sides?*

GROOVING. 113. *Show how to cut a groove with hand tools.*

114. *What is the difference between a groove and a dado?*

HINGES. 115. *Show how to fit chest or box hinges—strap or surface hinges—T hinges—door hinges, etc.*

INLAYING. 116. *Show the general principle of inlaying,—how to lay out, cut, fit, glue the parts, and smooth the surface.*

JOINTS. 117. *What is essential in making a good joint?*

118. *What is usually the first thing to do before laying out joints for good work?*

119. *In what ways may butt joints be fastened?—how strengthened?*

120. *Show the use of corner blocks and other devices for strengthening angles, etc.*

121. *What is a draw-bolt joint?*

122. *Show various ways of making end joints.*

123. *Show common ways of splicing to get greater length.*

124. *Show how to make a cross lap or halved joint—an end halved joint —a middle halved joint—beveled and dovetailed forms.*

125. *Show forms of rabbeted joints.*

126. *When would you use a dado joint? Show how to lay it out and how to cut it with hand tools.*

127. *Show a joint combining dado and rabbet.*

128. *What is a gained joint?—a notched joint?—a cogged joint?*

129. *What joint would you use for shelves, pigeonholes, etc.?*

130. *How can you avoid bruising the edges of matched boards when pounding them into place?*

131. *What is a splined joint for edges? How should the grain of the spline run, for strength?*

132. *What is a mortise and tenon joint?—a through mortise?—a blind mortise?*

133. *When is a through mortise best?*

134. *Show the process of laying out a mortise—the proper proportions of the mortise and tenon.*

135. *Show how to cut the mortise,—several ways. Which do you prefer? Why?*

136. *Show how to lay out and cut the tenon.*

137. *What is a stub mortise and tenon? When used?*

138. *Show the process where the tenon is cut on all four sides.*

139. *Show the principle of wedged tenons—wedged blind mortise—other forms of wedged and keyed tenons.*

140. *Show how to lay out and cut a keyed through mortise and tenon.*

141. *Show how to pin a tenon. What is drawboring?*

142. *Show tongue and groove and mortising combined, as for a door.*

143. *What form of mortise and tenon would you use for the joints of a table where the rails join the legs?*

144. *How can you strengthen such a joint?*

145. *When may a round tenon be used?*

146. *What are dowels and what is doweling?*

147. *Show the process of laying out the work, boring, fitting the dowels and putting the parts together.*

148. *Show the principle of wedging dowels.*

149. *What is a mitred joint? Its advantages and disadvantages? For what is the mitre a suitable joint?*

150. *Show what frequently results from mitring wide pieces flatways.*

151. *Show how to lay out and cut a mitre.*

152. *If all the four joints of a mitred frame do not fit, what can you do?*

153. *What two things are essential in making a rectangular mitred frame?*

154. *Show how to nail a mitred joint, how to glue it, and how to clamp it.*

155. *Show ways to strengthen mitred joints.*

156. *What is the simplest way to saw a mitre?*

157. *What is dovetailing and what are its advantages?*

158. *Show the processes in box dovetailing—lap or drawer dovetailing—mitre (or blind) dovetailing.*

159. *Show how to make a coped joint. When desirable?*

160. *What is a rabbeted edge joint?—a fillistered joint?—shiplap?*

161. *Which boards, with regard to the way they are sawed from the log, are the best for glued joints?*

162. *How is a glue-joint often reinforced?*

163. *How should you arrange the grain of narrow pieces to build up a wider surface? Why?*

164. *What advantage has a housed joint?*

165. *How can you strengthen a right angle in light construction?—for heavy work?*

166. *What is a bird's mouth joint?—for what used?*

167. *What is a slip joint, or a slip mortise and tenon, and for what used?—a multiple slip joint, or lock corner, and for what used?*

168. *What advantage and disadvantage in gluing flat surfaces to form a thicker piece?*

169. *How should you arrange the grain in such cases, except for plywood?*

170. *How are columns, cylinders, silos, and other curved forms often made?—how clamped and fastened?*

171. *Show ways to build up other circular or curved constructions. How should the grain be arranged in the different pieces?*

172. *Show how to fasten the top of a table to the frame beneath.*

173. *What is a hopper joint? Show how to make it.*

LOCKS. 174. *Show how to fit a chest or box lock—a common drawer lock—a rim lock for door—a mortise lock for door.*

RABBETING. 175. *What is a rabbet? Show how to cut one with hand tools.*

REPAIRING. 176. *Show how to refit tenons and dowels, and to reinforce weak spots—to fill holes and defects.*

ROUNDING. 177. *Show how to round a stick or an edge.*

SCRIBING. 178. *Show how to make one piece fit another by scribing. Illustrate by several examples.*

SHELVES. 179. *What joints would you use in fitting the ends of permanent shelves for nice work.*

180. *What common ways of fitting the ends of movable shelves?*

SHINGLING. 181. *Show the process of shingling.*

SPLITTING WOOD. 182. *In what ways is splitting wood done most easily?*

VENEERING. 183. *What are veneers?*

184. *Show the general process of applying the veneer and of securing in place with cauls or hammer.*

COMMON WOODWORKING MACHINES AND THEIR USES

582. **All who work in wood,** even if they do not use machinery themselves, should be familiar with the general principles on which the machines work, should know what they can do, and how to avoid injury from them.

The beginner should learn under the supervision of an experienced operator. Each machine should be kept in good order, properly adjusted and lubricated, and the cutting-edges sharp. Also, while using a machine, the operator should attend strictly to what he is doing. This can not be impressed too strongly upon him, or upon others who might distract his attention.

There are now so many designs and arrangements for each kind of machine, and the progress of invention is so rapid, that no book can include all the latest developments, for there is as yet no last word on the subject of machinery. Therefore the special study of such machines as are in use in each workshop should be made from the machines themselves.

583. **The most important machines for general woodworking** are the Circular-saw, Band-saw, Planer, Jointer, Moulder, Boring-machine, Sanding-machine, Mortising-machine, Tenoning-machine, Jig-saw, Turning-lathe, Scraping-machine, Spraying-machine, and Rubbing-machine. There are many others for special purposes, and others which automatically perform several operations at once. Combination machines often save expense and space, and are useful in a small shop; but if used by many persons time is wasted in changing the adjustments and in waiting for one's turn.

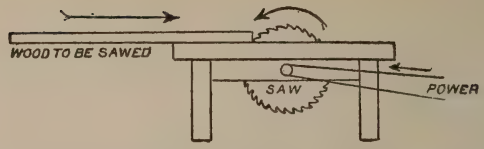
Separate machines with independent motors are best. Machines should be securely bolted to a firm foundation, and be free from vibration.

584. There is an element of danger in all machines, and even in the use of the common hand tools, but the scroll-saw, lathe, band-saw, and sander are safe machines if used with reasonable care. The others (and the band-saw also) should be used only with proper safe guards. The presence of the guards also keeps in the operator's mind the fact that there is danger to be avoided. Not only the cutting parts, but belts, gears, shafting, pulleys, sprockets, etc., should be guarded. Those who are careful use woodworking machines constantly without injury. Those who are careless are likely to be seriously hurt; and every beginner should be carefully coached in regard to the peculiar dangers of each machine.[1] With machines having fences or gauges for guiding the work, the "joint-edge," or "face-side," (**27, 72**) of the wood is kept against the fence or gauge. The Swing cut-off saw (or the bench-saw) is usually the first machine used, to cut the pieces roughly to length. The Jointer next makes joint edges and face-sides; the Circular-saw cuts to accurate dimensions, allowing for any necessary planing or smoothing; the Jointer, Scraper, Sanding-machines, etc., smooth the parts; Spraying and Rubbing-machines finish the work.

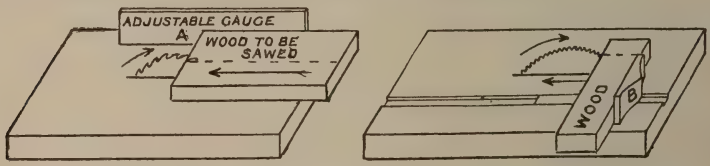
CIRCULAR SAW

585. Circular saw. A disk of steel with teeth on the edge, mounted on a shaft or arbor, and revolved by power. Large saws cut logs into lumber. Smaller ones (bench-saws, swing-saws, etc.) do most of the work formerly done by hand sawing.

[1] Projecting set-screws should not be used on revolving parts. The floors near the machines should not be slippery. Where enough work is done to justify their purchase, self-feeding machines are usually safer and more efficient.

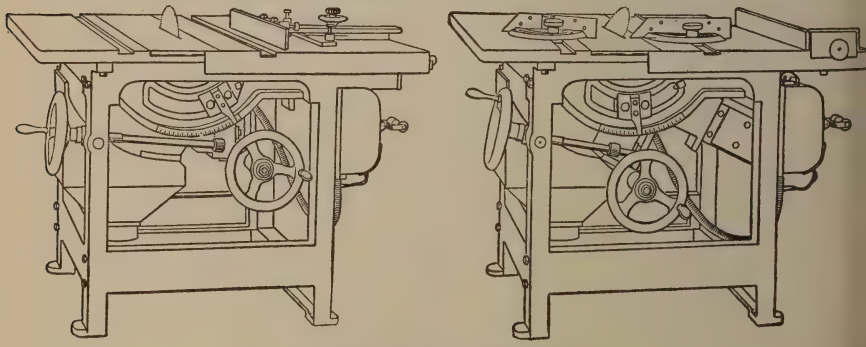


586. Showing simple principle of a saw bench. The operator pushes the wood against the saw, which revolves toward him. Rip sawing is shown in this case.



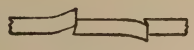
587. Showing how the wood is guided for these fundamental operations. A is a gauge or fence to guide the wood for ripping. Its distance from the saw can be adjusted. B is a sliding gauge to guide the wood for cross-cutting.

588. Showing saw (at the left) in normal position, at right angles to the table. Also showing adjustable ripping gauge. Some gauges have a quick and a slow adjustment.

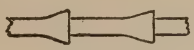


A MOTOR-DRIVEN BENCH SAW

Showing saw (at the right) tilted for bevel sawing. Also showing adjustable cut-off gauge, sliding in dovetailed grooves, for cutting at a right angle or at other angles.



SPRING SET



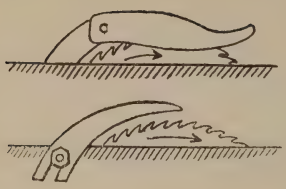
SWAGED

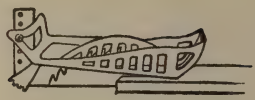
589. The teeth of the saws are similar to those of hand saws (99).[1] Many prefer to have the rip-saw swaged instead of set in the common way.

590. The saw can be raised or lowered or tilted for sawing at an angle. With some machines the table tilts instead of the saw, but it is better to have the saw tilt. Sometimes part of the bench-top, instead of the cross-cutting gauge, slides or rolls. The ripping gauge can also be tipped to rip at a bevel, and the cross-cutting gauge can be turned to saw at any angle. With various adjustments almost any kind of a straight cut can be made. Even the simplest type of machine, with few adjustments, saves much of the measuring, gauging, squaring, marking, testing, etc., necessary with hand work. The machine should be so placed that the operator faces the light. Some machines have two revolving arbors, to save changing saws, so that either a ripping or a cross-cutting saw can be used quickly, the other being lowered below the table.

591. To change saws, unscrew nut, take off washer, put saw on arbor with the teeth pointing toward the front. Replace washer and nut. Screw the nut tight, but do not force it very hard with the wrench, for the motion tends to keep it tight.

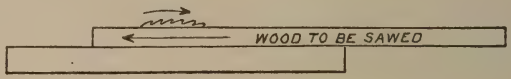
[1] Mitre or combination saws, concave-ground saws, "novelty" saws, are so made that they cut smoothly for both ripping and cross-cutting. These are very desirable for fine work and to save changing saws frequently. The speed of the saw shown is 3,450 R.P.M. (revolutions per minute). A saw will not work well if run at either an excessively high or excessively low speed. Of the two extremes, too slow speed is the safer. If a saw heats, see whether the teeth are set properly. There are no definite limits to the power required for a bench-saw. Three to five H.P. (horse power) is usually sufficient for fixed shop machines, while the little portable ones (624) will do good work with stock not over 1½" thick, if fed at a moderate speed, with only ¼ H.P.





592. A safety guard and a spreader lessen the dangers. There should always be a spreader or splitter behind the saw, to keep the kerf from closing, and to prevent waste pieces being caught by the teeth at the rear and hurled forward.[1] A safety guard should also be used. There are many forms.[2]

593. See that the saw is sharp, and that the splitter and safety-guard are in place. Roll up your sleeves and have no dangling clothing.



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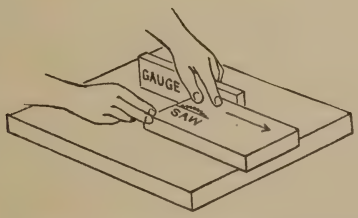
[1] "The spreader should be slightly beveled on the inner edge, and slightly thinner than the saw kerf, but thicker than the saw disk. It should always be securely fastened in careful alignment with the saw, and about $^3/_8$" behind it."—*Simonds Manufacturing Co.*

[2] "In construction, the guard should be light, so that it may be easily handled; should be substantial, and with rigid support, to avoid vibration and consequent danger of contact with saw. The softer metals are usually considered better material for the hood as contact of the saw with the hood is not so likely to result in a broken saw. The guard should be so constructed that it will automatically adjust itself to the varying thicknesses of the stock; it should be sufficiently open to give the operator a reasonably clear vision of the saw blade while in operation. The supports should be so set that they will not interfere with the work. The guard should be permanently attached to the machine so that it cannot be readily removed. The hood, however, should be so constructed that it may be swung out of the way for special work to which the guard cannot be adapted. The guard should be so arranged that it can be adjusted to the tilting of the saw table without interfering with the free working of the saw."—*Simonds Manufacturing Co.*

594. Have the saw project above the table only enough to cut through the wood,—never more than ¼″ above it.[1] Keep the safety-guard almost touching the wood. Turn on the power yourself, for safety. Stand close to the saw-bench. Let the saw get up speed before beginning to cut.

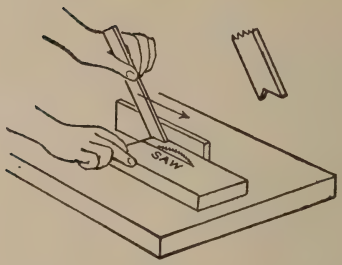
595. Rip sawing. Before starting the machine, set ripping gauge at a distance from the saw equal to the width required to be cut, using the rule, or the scale on the table, if there is one. For accurate work, test by sawing a piece of waste, and measuring the width actually cut. If edge-planing is to be done afterwards, allow a little extra width. With a good saw in good condition and with good wood, the cut is often so smooth that planing is not needed. The wood must have one *straight* edge—a joint-edge (**27**)—to slide against the gauge. This is essential.[2]



596. To saw; if the gauge or fence is on the left side of the saw, as shown, keep the left hand close to the gauge, with some of the fingers hooked over it, while the right hand is at the right hand corner of the board, to keep it pushed against the gauge. If the gauge is on the right side, the hands will be reversed of course. The edge of the wood must be kept against the gauge all the time. Push the wood through, past the saw, with the hand, only when there is a wide space between the saw and the guide.

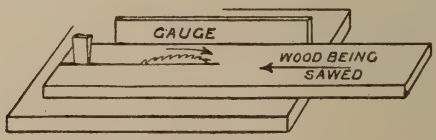
[1] There is less danger of friction against the saw blade than if a large portion of it is above the table, the teeth cut at a better angle, and have less tendency to throw the wood.

[2] In an emergency the expedient shown in **603** can be resorted to.

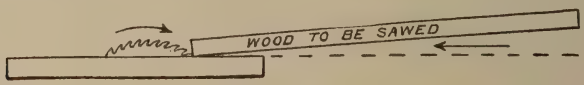


597. When this space is narrow, push the piece through with a stick having a V-shaped notch at the end. Important, for safety.

598. If there is no splitter, and the saw becomes bound by the kerf closing, open it with a thin wedge behind the saw. If the kerf closes at the beginning of the cut and binds the saw, draw the wood back and start again, to enlarge the kerf at the end. Sometimes you can reverse the piece and saw better from the other end.

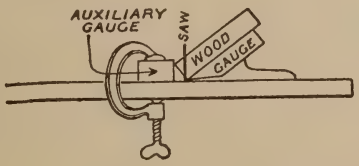


The distance between the saw and the fence should be very slighly greater at the rear than at the front, to give clearance. If the wood pushes through hard for no apparent reason, examine this adjustment.



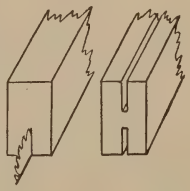
599. When beginning to saw a long board, raise the end you are holding slightly at first, then lower until the board is flat on the table.

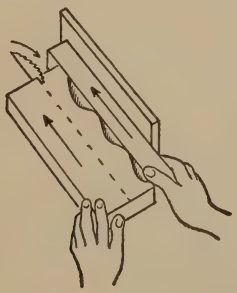
600. To stop ripping, or to remove the board instantly, raise the end you are holding.



601. **If the wood tends to slip away from the ripping gauge** when the latter is tilted at a bevel, clamp a piece of waste wood on the table so as to form an additional gauge on the opposite side of the saw.

602. **To split a piece too thick for the saw,** remove splitter, cut part way through on one side, turn the piece over, end for end, and saw the remaining thickness. If you cannot cut half way through, rip the remaining part with the band saw (640), or by hand.

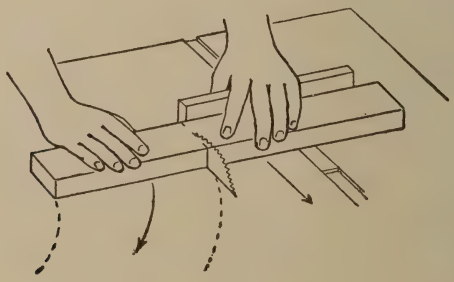




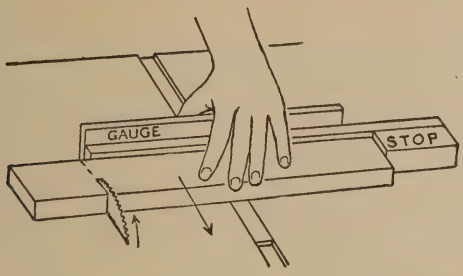
603. **A crooked-edged piece can often be ripped,** if necessary, by running a straight-edged piece through with it.

604. To saw for a glue-joint use a fine saw in the best condition,—either a cross-cut, or a concave-ground mitre, or a combination saw. The edge of the wood which comes against the ripping gauge must be straight. If not sure of the straightness, saw the piece a trifle too wide, reverse the edges, saw again, reverse, and saw to width. With care, strong and inconspicuous joints can be made quickly with the circular saw. See *Jointer* (654), and *Plane* (146). When much ripping is done, a self-feeding rip-saw is best, for accuracy, speed, and safety.

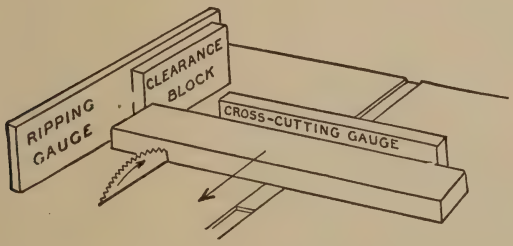
605. Sawing across the grain. If the cross-cutting gauge is on the left of the saw, place the wood in position, hold it firmly against the gauge with the left hand, and push gauge and wood steadily, but not rapidly, against the saw. At the end of the cut, swing the piece cut off away from the saw (as shown by the dotted lines) with the right hand, so that it cannot be caught by the teeth at the rear. A long piece may have



to be steadied by the right hand, but do the pushing on the left side only, or you may bind the saw. Some gauges slide on both sides of the saw. Sometimes with large or heavy stock it may be necessary to use both hands to keep it firmly against the gauge, but stand toward the left side and keep the right hand and arm well to one side of the saw. If the gauge is on the right side of the saw, reverse the hands of course.



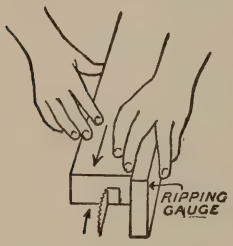
606. " Stop " for duplicating lengths. To cut a number of pieces of the same length, use an adjustable sliding attachment with a stop at the end, fastened to the cross-cutting gauge, to give any desired length. If there is no such attachment for the gauge, a strip of wood with a block nailed to it for a stop can be used as shown.

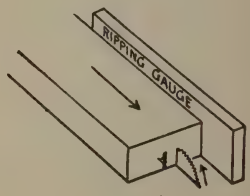


607. Clearance block for duplicating lengths. A stop (clearance block) is placed against the ripping gauge when cutting a number of short pieces of equal length. No part of the stop should be opposite any part of the saw, but nearer the operator, as shown. Slide the wood along the cross-cutting gauge until it hits the stop. Then push gauge and wood forward and cut off the piece. This gives the part cut off "clearance." This is important, for otherwise it is likely to become caught between the saw and the ripping gauge and to cause trouble. A narrow strip from the end of a wide board can be cut safely by the ripping gauge without the stop, but for a

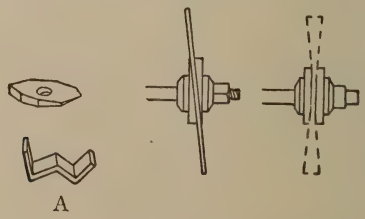
piece as long as it is wide, or longer, use the stop. Ripping gauges with metal stop-attachments are in common use.

608. A push-piece can sometimes be used, to prevent the parts which are cut off catching or being thrown back.





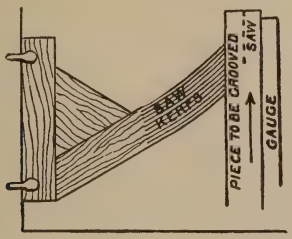
609. Grooving and Dadoing. Thick saws and special cutters (to be used in place of the saw) are made for grooving and dadoing. To cut a groove with a common circular saw, adjust the saw so that it will cut only the depth required for the groove or dado, make a kerf at each side of the groove, and remove the wood between by a series of parallel kerfs, or with the chisel. Two saws with a collar between can be used. Where the size of the groove must be exact, test first on a piece of waste wood. Solid grooving saws are also used.[1] The board



A

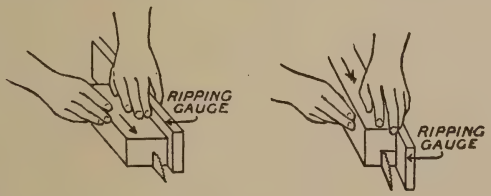
[1] Where much grooving is to be done, if you have no special cutter, the common circular saw can be "wabbled." Use a thick saw. Make a pair of thin wedge-shaped collars of wood and place one on each side of the saw, pointing in opposite directions. This will throw the saw out of its usual vertical position on the arbor, as shown. Thus the cutting edge will wabble from side to side, as the saw revolves, and will make a wide kerf. The width of

must be pressed tightly against the table as well as against the gauge. A spring attachment is sometimes used to do this.



610. A wooden spring board can be used to keep stock against the splitting gauge.

611. Using dado head. A "push-block" can be used to prevent tearing the wood at the edge nearer you. Be sure the knives of the cutter head are tightly bolted in place.



612. Cutting a rabbet with circular saw. Adjust the saw to project above the table the depth of the rabbet, and set ripping-gauge at width of rabbet. Start the machine, and test both adjustments by sawing into a waste piece. When cor-

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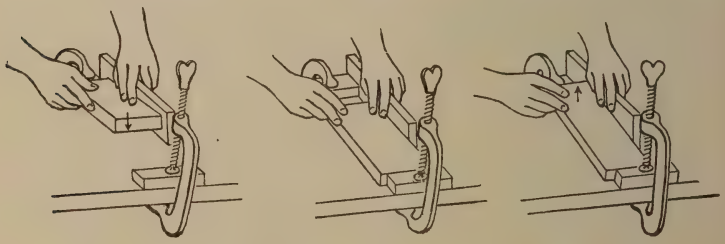
the cut depends upon the slant of the collars, and can be adjusted by turning one of them to alter their relative positions. Test with a piece of waste wood.

A simple way is to fold the necessary thickness of cardboard or some similar substance (A), and insert equal thicknesses above and below. This ensures tightness and stiffness of the saw, as the hardest cutting is done with the teeth which are on top and beneath when the saw is being adjusted. After the saw is fastened in place, a little tightening with the wrench will compress the pasteboard wedges more, and thus alter the width of the cut.

rect, saw a kerf for one side of rabbet, as shown. Stop the machine, adjust saw and gauge to cut the other side of the rabbet, with the wood on edge, as shown, and cut in the same way. If the rabbet is to be cut across the end of the wood, use a cross-cutting saw. Special cutters can be used.

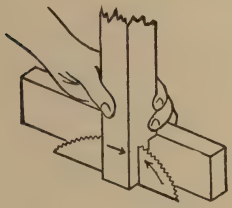
613. **A rabbet can be cut from one side only,** and the roughness trimmed with the chisel.

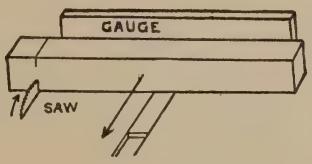
614. **To cut a stop-rabbet, or a stop-groove,** or a slot—not extending to the ends of the piece, have the saw project above the table the depth of the rabbet or groove or slot. Start the saw, and test the depth of cut by sawing into a waste piece. Stop the machine, and clamp "stop-blocks" to the table (as shown below) so that the wood cannot be pushed further forward or backward than is necessary to make the rabbet.



615. **Start the machine.** Hold the piece firmly, place the nearer end against the nearer stop, the edge against the gauge, and carefully lower the piece onto the saw, until the wood lies flat upon the table. Push the piece along against the gauge until it reaches the further stop. Then carefully raise the nearer end and remove the piece. Trim ends of the cuts to shape with chisel. This operation, requiring at least partial removal of the safety guard, must be done with care, to

prevent the hands being caught by the saw or the wood being thrown back.[1]





616. Cutting a tenon. Adjust the saw and ripping gauge to cut the side of the tenon. Test with a waste piece. Place the face side of the piece against the gauge, and saw as shown. Then adjust the gauge for the other side, and saw with the face-side against the gauge.[2] Then set the ripping gauge and saw, for cutting the shoulders (stop can be used), and saw them. If several tenons are to be cut, saw all the sides, shoulders, etc.,

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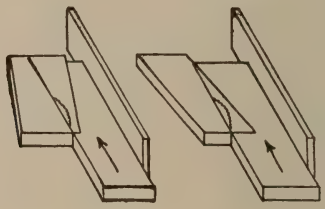
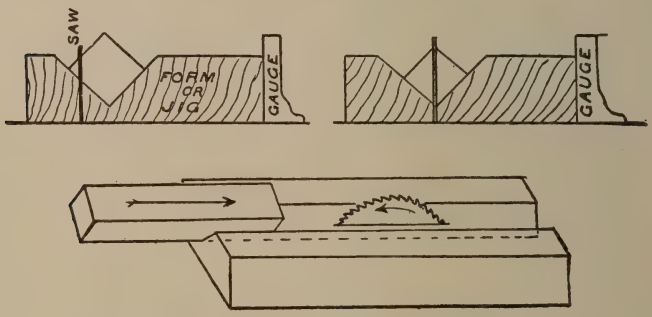
[1] Such work can be done by marking on the upper surface of the wood opposite the ends of the projected rabbet, and also on the gauge, or on the bench-top, opposite the points where the edge of the saw rises above the bench-top when adjusted to cut the required depth. Then place the piece so that the further marks agree, lower it carefully upon the saw and push it along until the nearer marks are opposite one another. But it is safer to use a block at each end. Such rabbets or grooves, etc., can be cut with a moulding-machine, and also on the circular-saw bench with a special cutter of the required shape.

[2] If the stock is accurately sized to thickness, it may not be necessary to keep the face side against the gauge to saw the second side, but simply turn the other side to the gauge.

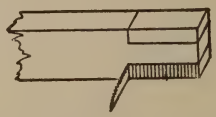
at the same time to save resetting the gauges. Two saws with a collar between can be used.[1]



617. Cutting tapers or wedges. Cut a notch of the shape required in a straight-edged piece, fit each piece into this notch, and push the two through together. If the tapering should come to a point, reverse the arrangement.

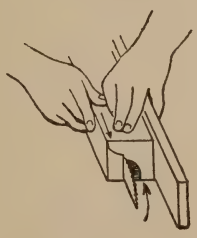


618. Jigs for cutting off corners and cutting fillets.

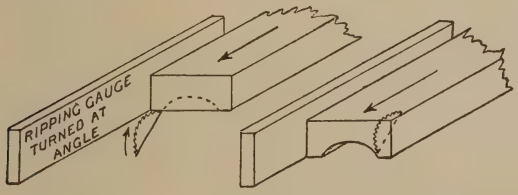


[1] A tenon can be cut with a series of cross-kerfs only, and the roughness trimmed with chisel.

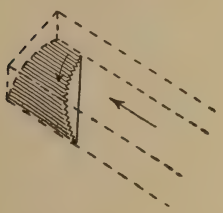
619. Roughing out mouldings with the circular saw by a series of parallel kerfs. Cutter-heads for such work, to use in

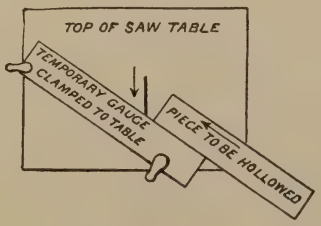


place of the saw, are made in various shapes and leave the surface smooth, which the saw does not.



620. Partially roughing out circular hollow groove by setting the ripping gauge at an angle, as shown. Hollow grooves of circular section cannot be cut exactly to the line by this method, but much of the wood can be removed. Staves may be hollowed in this way with a stiff, sharp saw by passing them over the saw at the proper angles. A board can be

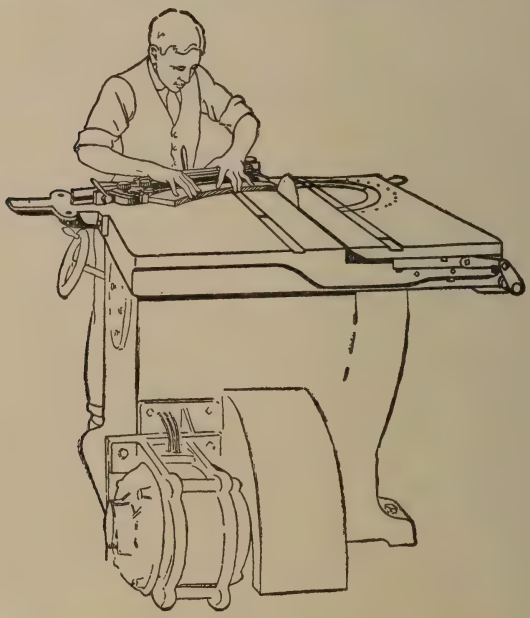




clamped across the table for a guide. The shape cut in these ways will never be a part of a circle but part of an ellipse,

because a circle when revolved ever so slightly becomes an ellipse. A circular groove can be cut to the line, but leaving a rough surface, by a series of parallel kerfs, as shown in **619**. A hand plane (core-box plane) is made for such work.

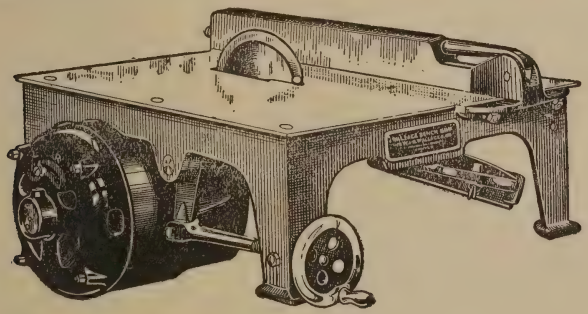
621. Convex curves can be cut approximately, if necessary, by making a series of straight cuts. This requires care, and should be done only by an experienced operator.



622. Circular segments can be fitted by gauges for the purpose.

623. By turning the gauges or tilting the saw as may be

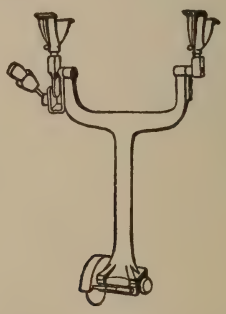
required, compound angles can be sawed, and many machines are equipped with graduated scales and adjustments by which almost any desired shape can be cut. Hopper joints (560), and similar angular shapes, can be cut by making the proper adjustments of the gauges and saw or table-top. Operations of this kind should be learned from the saw which is in use, under the direction of a competent operator. If a machine has no graduated adjustments, a great variety of angles can be cut by contriving forms or jigs to hold or control the wood so that the desired shape can be cut.



624. **Small portable machines,** of various designs, to be run by the electric lighting current, are in successful use. While large and heavy sawing should be done with large machines, a great part of the work of the beginner, amateur, and general student can be handled satisfactorily at comparatively slight expense with little machines of this type. They are in no sense toys, but will do small work economically, even where large machines are installed.

625. **Avoidance of danger.** Always use safety guard and splitter, except for the few operations which require their removal. A small cross-cut saw is safest for the beginner. The saw should be sharp. Many accidents are caused by dull saws. Roll up shirt sleeves. Start the saw yourself, to avoid its being started before you are ready. Keep mind and eyes wholly on the sawing. If you cannot do this, stop the machine

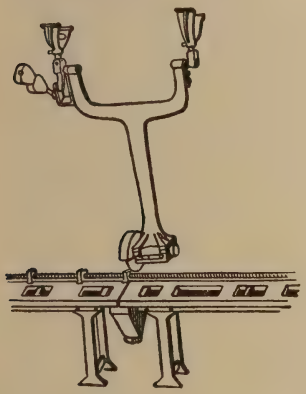
and wait until you can concentrate on the work. Push stock clear past the saw and off the bench, and keep the saw-table clear. Bring stock back at one side, never above the saw. Never reach over the saw while it is in motion. Form the habit of standing out of line when there is a possibility of pieces being thrown. Never lower the face to sight along the work while sawing. Have some one help you when ripping or cross-cutting very long stock. The rear of the saw is fully as dangerous as the front unless protected. Sawing stock free-hand, without fence or gauge, is dangerous and should be done only by an experienced operator. Use extra care with warped or winding stock. See that the floor is not slippery around the saw-bench. For narrow splitting, use a push-stick. In case of trouble, immediately shut off the power.[1]

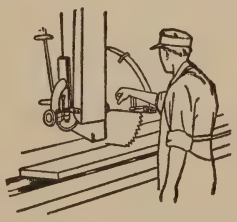


626. Swing saw. Used to cut off long stock before dressing to exact dimensions. It is so balanced that the saw, when not in use, is behind the rear edge of the table, leaving the table clear. Always use a good safety-guard, and see that there is a device to prevent the saw from swinging out beyond the

[1] The avoidance of danger can be taught by the use of a dummy. For example, erect a wide board in front of the saw. Stand safely to one side or behind the saw (as the case may require), allow a board to be caught by the teeth of the saw and projected toward the dummy operator. In the same way, allow small pieces to be caught at the rear of the saw, etc. The result of such demonstrations is more impressive than warnings.

front edge of the table. If equipment be limited, the work of this saw must be done with the bench-saw or by hand. There are various forms of swing-saws. The details of construction, adjustments, etc., should be learned from the machine you are to use.





627. To saw, place the lumber on the long table, move it to the right or left to the desired point, using the scale on the table. To make the cut, pull the saw toward you. Because the saw revolves toward you, pull it steadily, but not quickly nor with a jerk, or it may cut into the wood so fast as to become stuck. The machine shown has the handle on the left side. In this case, stand so as to grasp the handle firmly with the right hand. If the handle be on the right side of the saw, grasp it with the left hand.

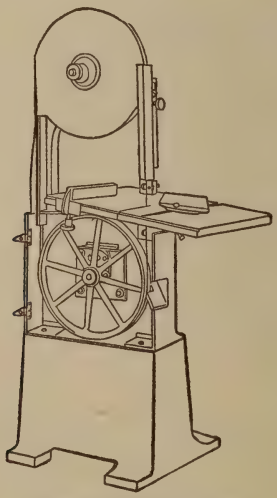
With a little ingenuity all the accidents likely to occur can be actually shown. For example, a rag hanging from a dummy arm and caught by the saw teeth will show that no human reaction can be quick enough to avoid injury. Safety guards may be painted red.

"The most usual accidents are caused by pieces being thrown back by the saw while ripping stock, strains in the lumber, resulting in the stock warping itself against the saw; knots or loose slivers being jarred against the saw by the vibration of the saw table or otherwise, and thrown against the operator; by the operator reaching over the revolving saw for stock and dropping or dragging the stock on the saw; sawing small pieces without

628. Small portable machines, operating from a light socket, for various fine operations like mitring, but based on the principle of the common swing-saw, are in use.

BAND SAW

629. Band saw. Used for both straight and curved work. The blade is an endless steel ribbon, with teeth on the edge, passing around two wheels, which are revolved rapidly. Large saws cut logs into lumber economically. The thin blade makes a narrower kerf than the circular saw, and saves lumber, time, and power.



PORTABLE BAND SAW

630. With the band saw used in shops the wood is fed by hand, and rests upon a table through the centre of which

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a guide and getting the fingers in contact with the saw; by slipping and falling on to the saw; by defective balancing arrangements on circular swing saws (626); lack of a device to prevent saw swinging beyond front edge of the table; by an occasional saw breaking while in use, due to same being defective; by the saw striking metal; using cracked saws, etc."—*Simonds Manufacturing Co.*

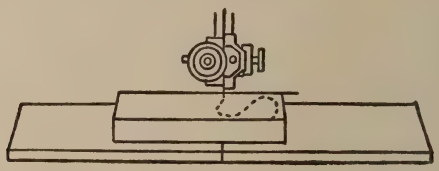
the saw passes. The power is applied to the lower wheel. If the wheels revolve at perhaps 500 or 600 R.P.M., with the thin blade cutting easily and continuously and making a narrow kerf, it is evident that it is a very efficient and economical machine.

631. **Always use safety-guards,** although the band saw is a comparatively safe machine.[1] The table can be tilted for sawing at an angle. The wheels must be properly aligned. The upper one can be raised or lowered to fit the length of the saw and to give it the right tension, and can also be tilted by a tracking device so that the saw, as it passes over the wheels, will "track" properly. Such adjustments are best learned from the machine you are to use. When not in use slacken the saw.

632. **The teeth point downward** and, with the small saws for shop use, are set (100, etc.) to give clearance, as with the circular and common hand saws. The blades for such machines range from $1/8''$ to $1\,3/4''$ wide. The width must be adapted to the work. A $3/16''$ blade is as wide as should be used for sharp curves, but for sweeping curves or for straight work a wider blade is better. A wide set makes a rougher cut than a

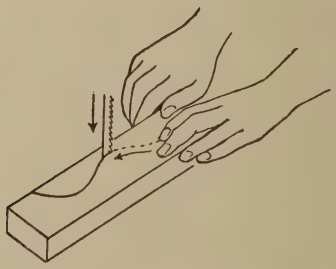
[1] "Accidents most common on band saws are those resulting where the stock is not securely held, with a consequent kinking and breaking of the saw. Severe injury often results from accidents brought about by the operator trying to remove waste pieces near the saw with the hand, or attempting to stop the wheel with hand, foot or stick when the power is shut off; attempting to adjust the gauge when the saw is running or the band flying off unprotected wheels in case of breakage. Other accidents are due to workmen's clothing becoming caught in the spokes or on the band of an unprotected wheel. Accidents are frequent through the carelessness of the operator getting his hand against the saw at the rear of the table, or sometimes getting the hands and head above the portion of the saw over the gauge. . . . Safety engineers agree that practically all of these accidents can be prevented by enclosing the upper and lower wheels with either a wire mesh guard or a solid enclosure; also the cutting edge of the saw above the table at the rear, as well as that part above the guide."—*Simonds Manufacturing Co.*

slight set, but cuts a sharper curve. The teeth are filed, set, etc., on the same principles as other saws already described. Filing, setting, brazing, etc., of band saws is best learned from a competent instructor.



633. Showing saw and its adjustable guide just above the table. The guide must neither bind the saw nor cause it to become twisted. If the saw bears against the guide it is likely to cause case hardening.[1]

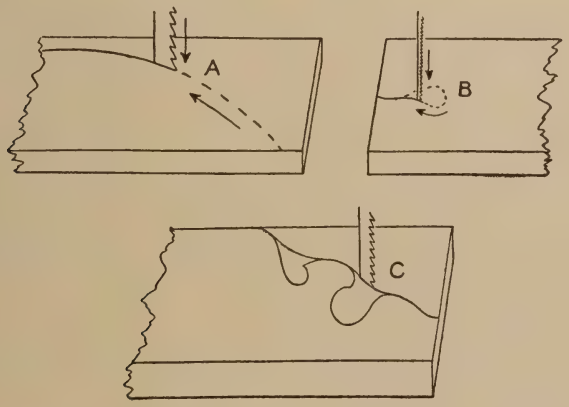
634. Before beginning to saw, look the machine over. Lower the upper guide close to the work. Turn the wheels over by hand to see that the saw "tracks" properly on the circumference of the wheels, and runs easily between the guides.



635. To saw, start the machine, wait until it has picked up speed, hold the wood lightly (not rigidly but securely), and guide it gently and easily against the teeth. Feed the wood to the saw only so fast as the teeth will cut it easily and freely.

[1] "The back guide should never be so close that the saw will come in contact with it. It is only placed there as a matter of precaution."—*Simonds Manufacturing Co.*

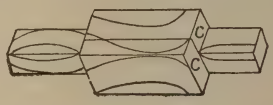
Avoid reaching around the saw while it is in motion. Do not try to turn the wood very quickly so as to twist the blade, nor to cut curves too sharp for the saw. To remove the wood while the saw is in the kerf, stop the machine, or saw out through the waste wood. Pulling toward you may pull the saw off the wheels.



636. Use a wide saw for a sweeping curve (A) and for straight work. When the edge must be left as smooth as possible, saw with the grain of the part to be kept. Use a narrow saw for a sharp curve (B). To cut a sharp curve with a saw too wide (C), as is sometimes unavoidable, first run past the sharp curve, and then work by short cuts up to the line; but it is better to use a narrow saw for sharp curves.

637. Shapes like the leg shown are best sawed from a solid square post. First mark the pattern and saw from one side (A). Then turn half over, mark the pattern again, and

saw to final shape. The second marking will be on a curved surface, therefore the pattern must be drawn directly on the wood or projected from the pattern first used. That is, a flexible pattern cannot be bent to fit the curved surface, for it would give a different curve from that already sawed.



638. The waste pieces can often be used to block up the piece for the second sawing (B), and sometimes can be used as blocking when the work is assembled with clamps. Such forms are often built up by gluing on pieces (C). This takes more time but less wood, and is usually the cheapest way. A solid piece is better in most cases, certainly for the beginner. See **439, 540, 541, 754.**

639. Using a dull saw, so that you have to force the wood against it, is working the saw beyond its proper capacity and is apt to cause trouble.

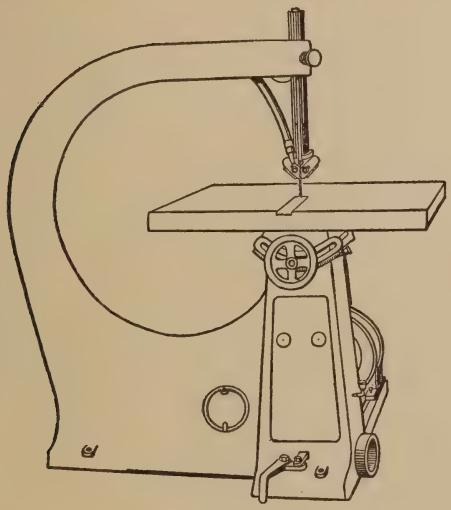
640. Re-sawing lumber into thinner stock is done with band saws arranged for the purpose. Attempting to re-saw wide stock with a common band saw is not to be recommended. One way to re-saw stock, if not too wide, is to split it from each edge with the circular saw (**602**) as deeply as the saw will cut, and then saw the part in the middle with the band saw (or by hand if necessary), the circular-saw kerfs helping to make the band saw cut accurately.

641. Small portable band saws are made, to run by the lighting circuit.

JIG SAW

642. Jig saw or scroll saw. Although superseded by the band saw for most work, the jig saw is necessary for cutting inside open work, "coring work"—which cannot be done with the band saw. The table can tilt for beveled sawing. As the

jig saw has a reciprocating, up-and-down, motion and cuts on the down stroke only, it is not so efficient as the band saw,

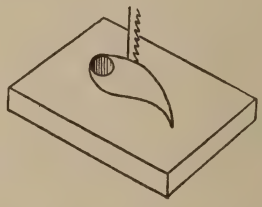


which runs so rapidly and cuts continuously. A jig saw will, however, do most of the curved work of the beginner or amateur easily, cheaply, and well. It is easy to keep in order, uses but little power, and is safe. The teeth must point downward. The tension should be such that the saw is tightly strained, but not over strained. Relieve the tension when not in use. If the tension is not automatically adjusted, test by hand. The size of the saw, etc., must depend upon the work, as with the band saw (632).

643. **To saw,** lower the guide near the wood. The sawing is done as with the band saw (635) or the hand scroll saw. Feed the work only so fast as the saw will cut easily and freely and without being bent or twisted. Avoid trying to turn very quickly when cutting sharp curves (636). A blower can be used to keep sawdust away from the line.

Excessively high speed is not an advantage with a jig saw.

The old-fashioned form with no upright post, the upper part being fastened to the ceiling, is sometimes desirable, because large work can be swung around and sawed in any direction, which cannot always be done with the band saw or jig-saw having an upright post.



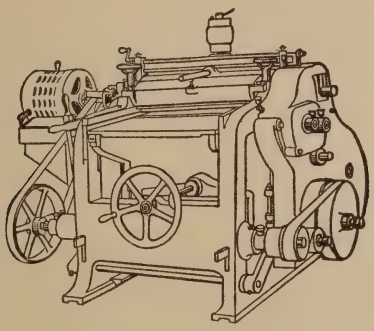
644. Sawing inside openwork. First bore a hole, unfasten saw, pass through hole, re-fasten, and saw to the line.

645. A foot-power scroll saw is excellent for the beginner or the amateur, is safe, comparatively cheap, and very efficient.

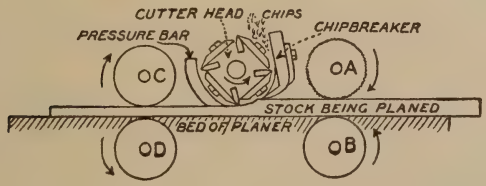
PLANER

646. Planer. Essential to a completely equipped shop, but can be omitted from a limited outfit much better than the circular saw, band saw, or jointer; and is of minor importance to the beginner or amateur because stock can be planed (or bought already planed) of any desired thickness almost

anywhere. After learning the adjustments from the machine itself, it is not hard to operate.

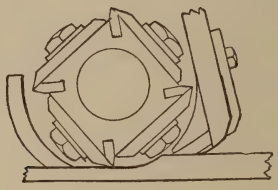


647. Direct motor-driven single surfacer.



648. Diagram showing action of single surfacer. You push the wood between the two feed rolls (A) and (B), which revolve in the directions shown. The corrugations of the upper roll (A) move the wood over the bed of the machine, under the chip-breaker, to the knives of the cutter-head, which plane little chips from the surface. These are discharged above the cutter-head as shown, and can be removed by a blower. The board next passes under an adjustable pressure-bar which presses it down upon the bed. Then the two smooth rolls (C) and (D), carry it through. The single surfacer planes the upper side of the wood, therefore if one side has been planed, or is flatter than the other, that side is placed down. This type of planer smoothes the wood, but does not make it flat. A warped

board will still be warped after planing, although slight irregularities will be straightened. To produce flat surfaces, one side must be made flat before planing. It can be made so with the Jointer (654) or by hand, if necessary.[1] With a double surfacer both sides are planed at once, and some machines plane all four surfaces.



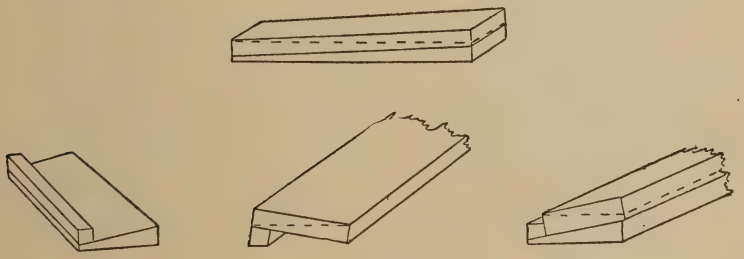
649. **The close setting of the knives** in the cutter-head and the nearness of the chip-breaker produce a similar result to that caused by the cap-iron and the front edge of the mouth of a hand plane (133, footnote).

650. **The thickness of the planing is regulated** by raising or lowering the table on which the wood is carried. If stock is to be made much thinner, pass it through the machine several times, planing equal amounts from each side to lessen subsequent warping (747). If stock is of uneven thickness, the first planing must be gauged by the thickest part. If several pieces differ in thickness, plane the thickest first. Take very light cuts at first, until you have learned by experience how to handle the different kinds of wood, rates of speed, etc. Feed the wood on a diagonal when you can.

651. **Adjustments, planer-marks, etc.** The adjustments and details of different machines vary, therefore they are best learned from the machine which you are to use, under the

[1] The rolls should bear on the wood only enough to carry it along. The machine shown will plane material from 1/16″ to 7¾″ thick. Single pieces 13″ long, or pieces 3″ long, fed one after another, can be planed. The rates of speed range from 20 to 60 feet per minute. H.P., 10 to 20.

direction of a competent operator.[1] The revolving knives make little waves or undulations on the surface. These planer-marks (137) must be removed, for nice work, by hand planing or by sanding or scraping. Ascertain how short stock can be planed by the machine you are to use.[2] The planer is probably not more dangerous than most machinery, but it is well not to stand behind the wood being planed.



652. A piece can be planed to taper lengthways by placing it on top of another piece of the required taper and running both through together, making a series of light cuts; or by attaching the piece to a form so that one end will be higher than the other. To plane tapering crossways, or from edge to edge, make a form or taper-board, by attaching a strip of the thickness of the desired taper to the underside of a board at the edge, and then planing the top surface down, as shown. When turned over this makes a form to hold the wood for

[1] The machine should be free from vibration, the feed should be steady, and the knives must describe a small circle at high speed to ensure the best work. Soft woods can be fed faster than hard. Smoothness of surface, as a general principle, is in proportion to slowness of feed and lightness of cut.

The in-feed roll is made up of sections 1″ wide which yield to the variations in the stock being planed, and adapt themselves to irregularities of glued-up work and to narrow pieces. This tends to prevent pieces being thrown toward the operator.

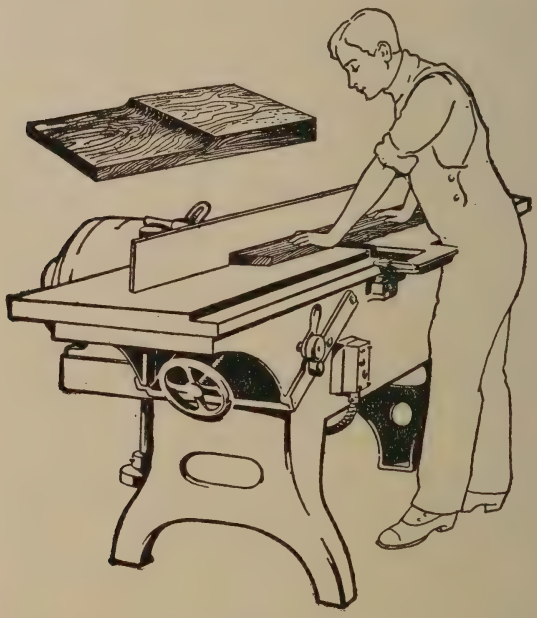
[2] A short piece can be pushed through with another piece so that the rolls can carry it along.

planing, which should be done with light cuts. A stick can be made octagonal by placing it in a cradle or form (155) and running both through together.

653. **Grinding, setting, and truing the knives** are now done by motor-driven devices. With old-fashioned machines, the edges of the knives are adjusted to be parallel by placing blocks of wood of equal thickness upon the bed below the knives.

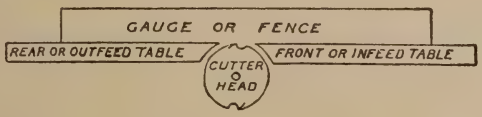
JOINTER

654. **Jointer.** Very important for planing and squaring edges and truing flat surfaces. Automatic safety guards should always be used.

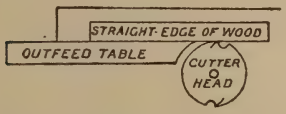


655. **The wood is held against the gauge** and passed along the table or bed of the machine by hand, over the rapidly

revolving knives, which are similar to those of the surfacer (649). The jointer does much of the work formerly done with hand planes. Also used to plane joints for gluing (see also 604) and for other operations. A true joint-edge and working-face (27) are quickly made. It is not a hard machine to use after learning the adjustments, but these must be skilfully made. The bed or table is in two parts. These can be raised or lowered independently.

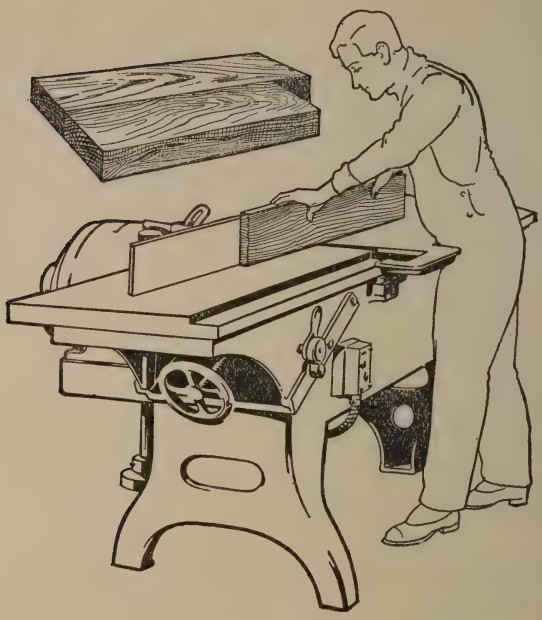


656. **The rear or out-feed table supports the wood after it has been planed** and should be on a level with the edges of the cutting knives when they are at the highest point. This is essential.

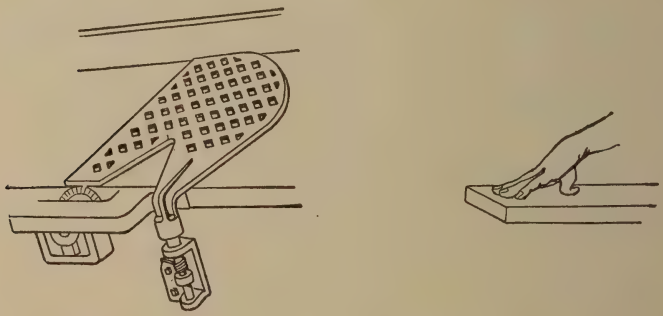


657. **To test this,** lay a wooden straight-edge on the rear or out-feed table so as to project over the knives, and revolve the latter slowly by hand. If they do not just touch the straight-edge without cutting it, raise or lower the rear table until they do. Another way is to plane from the end of a piece for a short distance, and see whether the planed surface fits exactly upon the rear table.

658. **To use the machine,** after seeing that the rear or out-feed table and knives are adjusted, as just shown, lower the front or in-feed table to the depth you wish to cut. If a square cut is wanted, test position of fence with try-square. See that the safety guard is in position, stand at the side of the in-feed table, with the left foot in advance, hold face-side or -edge of the wood firmly against the gauge, and begin to



push the stock over the knives. The adjustments can first be tested by running a waste piece over the tables. Push with the

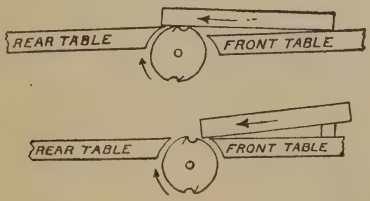


fingers, not with the whole hand, and keep them on top of the wood, not over the sides or ends, except when necessary.

In planing flat surfaces, feed diagonally when you can. As soon as you have passed the wood well by the cutters, keep the planed part pushed down flat on the rear (out-feed) table, which is *necessary* in order that the surface planed may be straight or flat throughout. Care must be taken in planing stock so narrow that there is danger in holding it down with

the hand. You can use a push-stick. Use different parts of the cutters for edge planing to avoid dulling one portion of the knives more than the rest.

659. To true stock which is not flat. If warped or crooked, place hollow side down. By holding the piece down with the palms of the hands on the rear table and rocking it slightly, you can tell where the highest parts are and can plane these off first as you pass the piece over the knives. If thin or flexible stock is not flat, press down lightly while planing, to avoid flattening with the hand, which would result in the surface being warped or winding after planing. Short pieces should be planed in some other way, as there is danger in passing them over the cutters.



660. To plane tapering, as in case of table legs, the rear table can be raised so that the depth of cut will gradually diminish. Clamp a stop on the in-feed table at the right distance for the taper; or, if you wish to taper part way only, support the rear end of the wood by a piece of waste. Repeat the planing until enough has been cut.

661. To taper wide stock crossways (from edge to edge), set the gauge one-half the width of the taper from the edge of the table, and set the in-feed table to cut one-half the depth of the desired taper. When cut a wide shallow rabbet is the result. Finally, move gauge back, and plane the piece in the position shown until the taper is formed.

662. The fence can tip. Chamfering, beveling, rabbeting, tonguing, grooving, beading, tenoning, and moulding, in

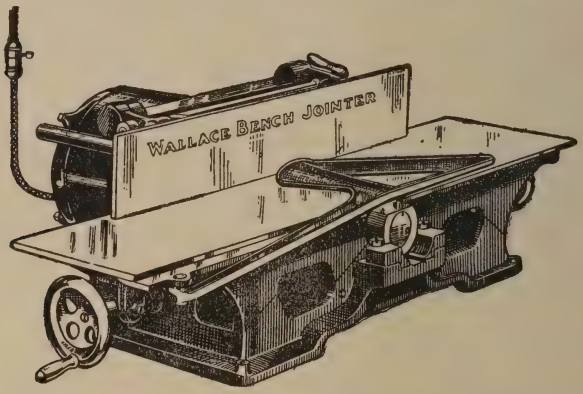
various forms, can be done with different attachments and cutters.[1]

[1] The edges of the knives must be parallel to the axis of the cylinder to which they are attached, as well as in line with the rear table; and the plane (flat surface) of the front table must be parallel with that of the rear table. Setting the knives requires care and should be learned from an experienced operator. Be sure that all set-screws, bolts, or other fastenings are tight, for serious injury can result from loose parts. Cylindrical cutter heads are used for safety. Modern jointers, like planers, have attachments by which the knives can be properly ground, set, etc.

A rabbet of moderate depth can be cut by moving the gauge to a distance from the edge equal to the width of the desired rabbet, as shown.

Tenons can also be made by fastening a stop to the out-feed table to

663. Small portable jointers to connect with an electric light socket will do most of the work of the beginner and

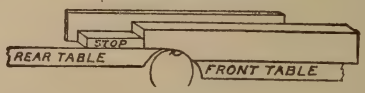


amateur at comparatively slight expense. They also save much time, labour, and expense, where large machines are installed.

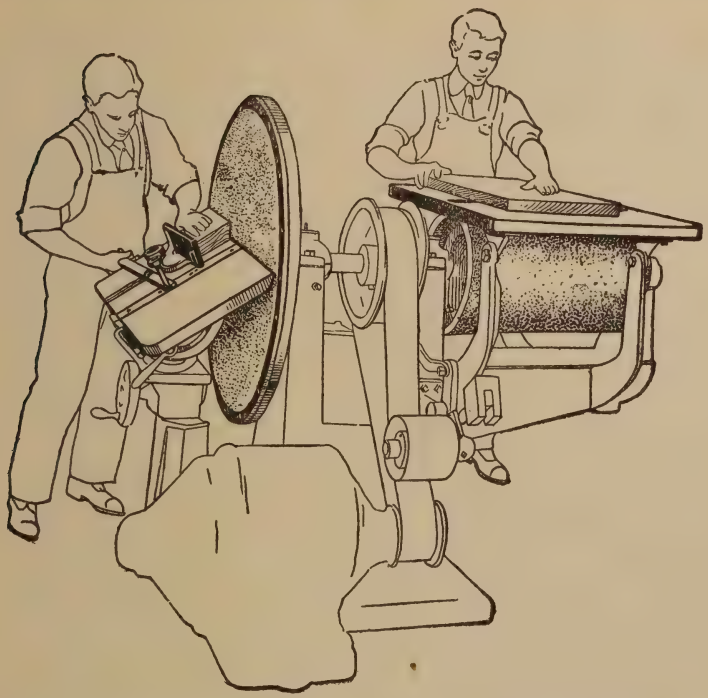
SANDING MACHINES

664. Sanding machines. The large drum sander is used for smoothing large flat surfaces. The drums are covered with sandpaper, and the wood is passed through the machine as through the planer. With a triple drum sander, the first drum carries coarse sandpaper; the second, a medium grade; and the third, fine paper for the final finish. With coarse paper only, glue-joints in hard, fine-grained woods can be made.

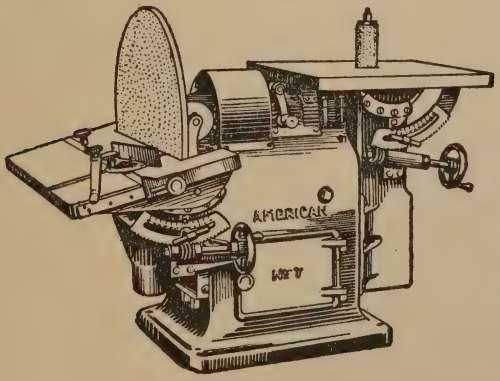
665. With small drum sanders the wood is passed over the table by hand, and sanded by a revolving sand-covered



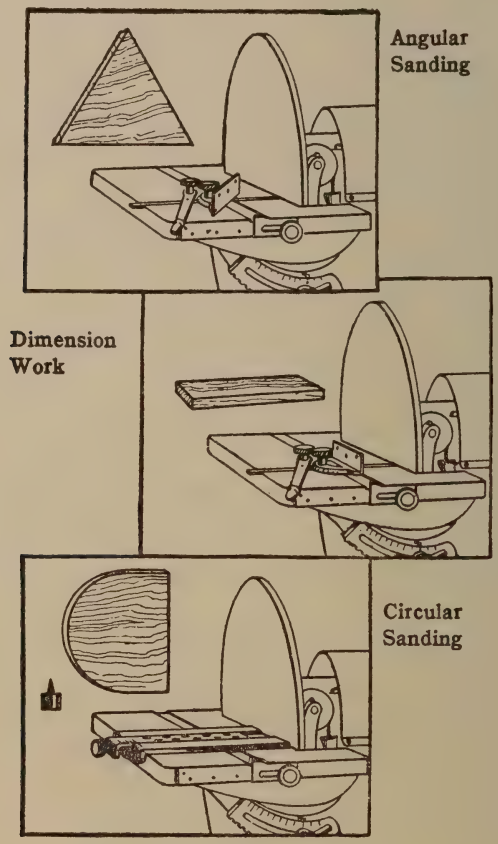
limit the length cut, and then planing successive cuts until the tenon is reduced to the desired thickness, as shown.



drum underneath. Such machines are comparatively cheap and do effective work. Even home-made ones do good service.



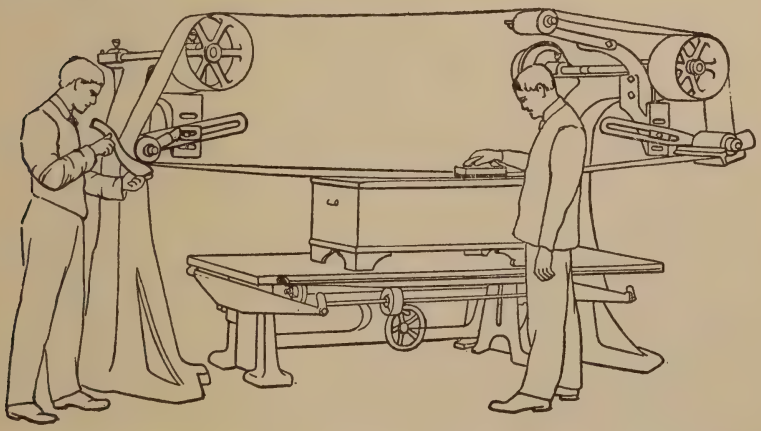
666. Showing principle of the disk sander. The disk is faced with sandpaper. When worn out, this is replaced by a new disk of sandpaper, easily glued on.[1] With some machines the paper is held by a band around the rim. The table tilts



[1] In sticking a disk to the disk wheel, rotate the disk to spread the cement evenly. Water-glass is sometimes used. Leave under pressure for some hours, to set firmly. Soak off old disks in hot water.

and the gauge can be set at a bevel. Angular and curved surfaces, as well as flat, can be sanded.[1] Small stock for built-up work can be prepared quickly for gluing, and many shaping and fitting operations done. Disk machines are made in numerous sizes. Large disks are advantageous, because the sandpaper near the circumference does the most work, therefore you can do more with a large disk than with a small one. Many small objects can be prepared for gluing economically by disk grinders, using waste scraps; and, after gluing, can be shaped by the grinders.

667. Spindle sanders are used for curved and irregular, and even flat surfaces. They oscillate up and down, and are made to tilt also. See **666.**



668. Hand-block belt sander. This type of machine is very useful, handles a great variety of work, and has many

[1] Jigs for sanding special shapes can easily be contrived. For example, a jig for a curve, as shown.

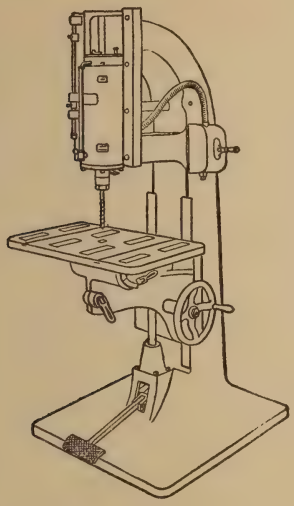
advantages. The operation is simple. The band-covered belt is brought into contact with the work by means of a hand-block or pad. This block-pad can be shaped to fit irregular forms. The table beneath, which supports the work, can be moved, as may be required. The sanding is done with the grain of the wood. Machines of this type are very versatile, because of the flexibility of the belt, and the various methods by which both uniform and odd-shaped work can be handled. Small shapes can be sanded at the ends of the machine. Such machines may require from 1½ to 3 H. P. Belt machines are made in different forms and with varying details, which can be readily learned from the machine you are to use.[1]

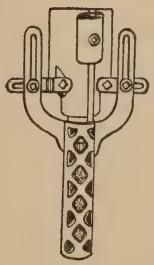
BORING MACHINES

669. Boring machines. In the industries boring is chiefly done by a great variety of machines which bore vertically or horizontally, by boring attachments to other machines, and by the use of jigs for special purposes. Power borers should have safety guards. The tables which hold the work are adjustable, and the boring is controlled by hand or foot. The face side or joint-edge of the work is kept against the gauge or fence.

670. In the vertical machines, the motor can be mounted directly on the boring spindle and both be raised and lowered together, according to the requirements of the work. The table, which supports the wood, can be raised or lowered according to the thickness of the stock to be bored, and can be tilted. It can have slots through which various kinds of fixtures or gauges can be clamped. The head carrying the

[1] For the ordinary work, belts of paper are used; about 6″ being a good width. For irregular shapes, cloth belts can be used of a width to suit the work. The length of the belts gives great flexibility, and also keeps the belt from heating. To join the ends of a belt, remove the sand for a short distance from one end, glue, lap, and clamp until dry. A belt-splicing contrivance can also be used.





motor slides up and down in ways. Adjustable stops regulate the depth of hole and the height to which the head returns. The bit is brought down to the work by foot pressure on the treadle. By releasing the foot pressure the head is raised and the bit withdrawn from the hole.

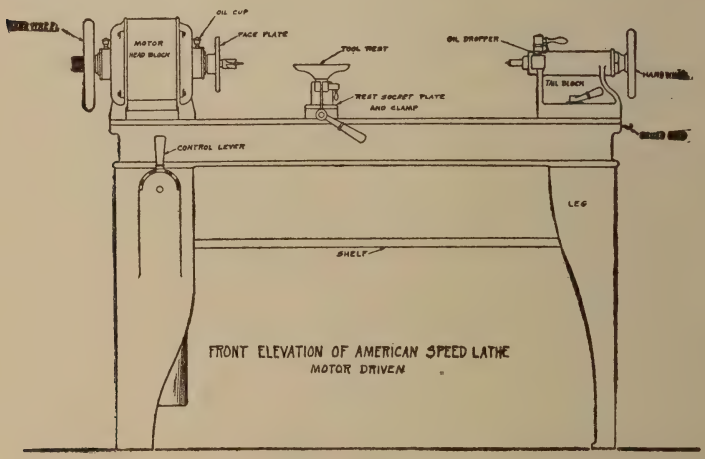
671. To bore, insert and tighten bit, adjust table vertically according to the thickness of the wood to be bored, and see that the spur of the bit centres on the right point for the hole. Start the power, and by using the foot-control lower the bit steadily until the hole is bored. If the hole is to go only part way through, a stop can be set to bore only to the required depth. Lower the bit, when not in motion, at the edge of the wood and then set the stop. If exact depth is important, test by boring into a waste piece.

While the general principle is similar in all boring machines, they differ in arrangement, adjustments, and the various details. You should learn these from the machine you are to use. A horizontal boring machine works on the same general principle as a vertical machine. Horizontal boring attach-

ments for circular saw benches are in common use. Cutters for routing, core-box work, etc., can also be used with boring machines. A post borer, or a bench drill, is useful within the limits of its capacity. Portable boring machines driven by electricity are made to hold in the hand, so as to bore in any position or direction. A safety guard for the bit is desirable.

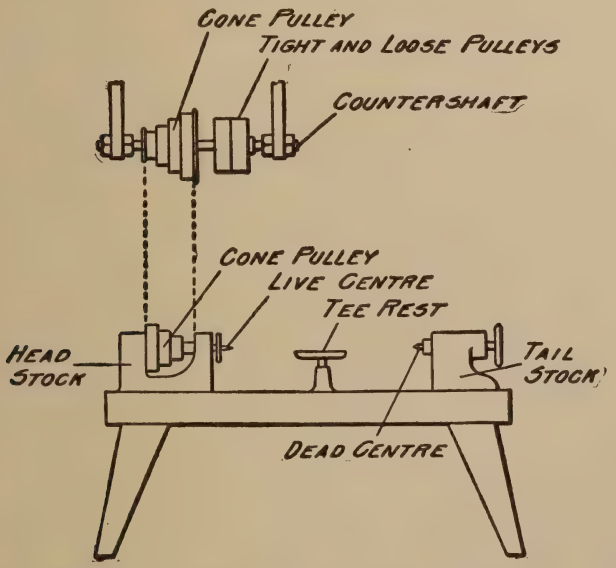
LATHE

672. Lathe. Most woodworking machines are of recent invention, but the lathe in its primitive forms dates from antiquity. Woodturning is a trade in itself, and is much better learned from a practical and experienced turner than from a book. All woodworkers should, however, understand the general principles of turning and the elementary operations, which are all that can be included in a general handbook. Turning requires concentrated attention and freedom from interruption, both on account of the work and to avoid accident.



673. A typical illustration of a lathe. Although the details of different machines vary, the general principle is the same

in all. For the common forms of turning, the wood is held between two points or centres, and is rapidly revolved toward the turner, who holds the edge of a tool against it, and thus cuts it into the desired shape.



674. Diagram showing general arrangement of a common lathe driven by belt from a countershaft.[1]

675. One of the centres (the one on the left) between which the stick is held, has spurs which enter the wood, so that when this centre is revolved the wood is also revolved. This is some-

[1] When the belt is on the smallest step of the cone-pulley of the lathe it will be on the largest step of the driving-pulley on the counter-shaft above. This gives the highest speed, for when a belt runs from a large wheel to a smaller the speed is increased in proportion to the sizes of the wheels. For the slowest speed put the belt on the smallest step of the countershaft pulley and the largest of the lathe pulley, for the speed is decreased when a small wheel is connected with a large one. Small work requires a higher speed than large. The "swing" of a lathe means the diameter of work which can be turned with it.

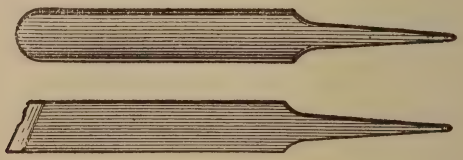
times called the "live" centre. The other centre is merely to hold the other end of the wood in place, and does not turn

LIVE CENTRE

DEAD CENTRE

with it. This is sometimes called the "dead" centre. A movable tee-rest for the tool is fastened in front of the wood, so that the tool may be held securely and steadily (673).

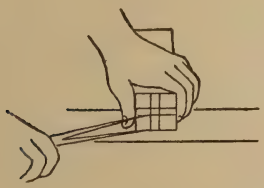
676. **Clear pine is the best wood to begin with,** though whitewood or other similar wood will do. Select pieces free from cracks, checks, or shakes, which might cause the wood to split while being turned. The operator should face the light, and it is well to have it from the right also. Different turners frequently have different ways of doing work and there is much opportunity for thought in so handling the tools as to do the cleanest and best work in the least time. Therefore carefully observe the effect of holding the cutting edges in different positions so as to learn to do as much clean cutting, and as little scraping, as possible. Handle the tools lightly and freely. Do not press hard and long at any one spot, on account of the friction.



677. **To turn a cylinder.** The tools needed are the turning gouge and the turning chisel. The gouge is usually ground with the edge rounded to correspond with the degree of curvature of the tool. For roughing out, however, it is sometimes ground squarely across. The chisel is ground on both sides and is usually a skew-chisel also. Experienced turners, however, are apt to grind with very little skew or squarely across. First, get out a piece of wood with the circular saw about

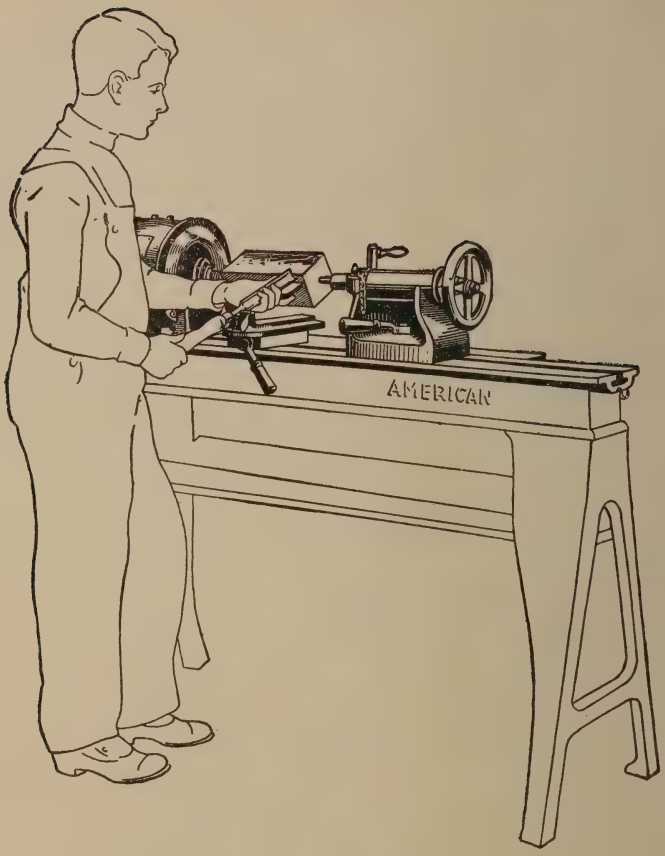
2″ by 2″ by 10″.[1] Find the centre of each end by drawing diagonals, or as shown below.[2] With hardwood a small hole can be started for the spur. Put a few drops of oil on the end of the piece where the dead centre will be inserted. Move the tail-stock (674) up toward the head-stock until the wood is held between the two, centring it by the marks just made upon the ends. Screw up the tail-stock until the spurs of the live centre are firmly fixed in the wood and the dead centre also forced well into the end. The wood must revolve freely and at the same time be securely held. Test this by first revolving by hand. Adjust the top of the tee-rest to be about level with the centres (673).[3] Fasten it as close to the wood as you can without danger of striking, before starting the lathe. Do not change it while the lathe is moving.

[1] The exact size is immaterial,—1¾″ square will do—but for the following elementary exercises this is a suitable size and can be economically cut from a 2″ plank.



[2] The centre can be found by using compasses as shown, or a gauge. This way can also be used for irregular shaped pieces, as the compasses will trace a small copy of the outline. The experienced turner centres small work by eye, gives the wood a few revolutions and, if necessary, makes a slight cut with a tool to detect any inaccuracy in the centring. By stopping the lathe and by tapping, or a slight movement of the piece, he adjusts it to run true. If the wood becomes overheated at any time, stop the lathe and oil again or loosen the wood slightly. Do not oil while the lathe is in motion.

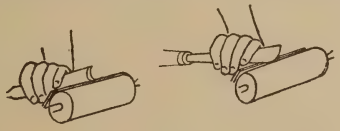
[3] The rest can be a little below the centres for small work, but for large work should be somewhat above the centres. This depends somewhat upon your own height.



678. Start the machine slowly.[1] Let it get up speed before beginning to work. Take a position with the feet spread so that you can stand firmly. It is usual to stand with the left side somewhat turned toward the lathe, and to keep the right hand, which holds the tool handle, against the body.

[1] The highest speed is usually right for these small elementary exercises but use the slow speed for the first roughing into cylindrical shape.

679. First rough out the shape with a gouge. The left hand can be held as shown, or underneath as in **682.** Begin some distance from the extreme end of the wood, lest the tool become caught. Begin with the edge of the tool so placed that it would cut at a tangent to the upper part of the cylinder, as shown. Then carefully raise the handle until the edge begins to cut. After dipping down into the wood in this way, move the tool along a little and dip down again, making a succession of cuts as shown at the right. If the cuts are made nearer together the bulk of the corners will be roughed off.

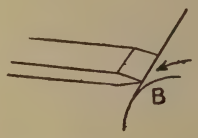


680. Then begin at the right-hand end and move the tool sideways back and forth along the stick until it becomes cylindrical. Stop the machine and move the tool rest to about $1/8''$ from the wood. Then start again. In smoothing with the gouge place the tool at first so that the basil and not the cutting-edge bears on the wood and then carefully raise the right hand a very little until the edge begins to cut. The tool can be turned over slightly so as to cut with either side of the edge, as shown, rather than with the extreme end, thus making a smooth shearing cut (**77**).

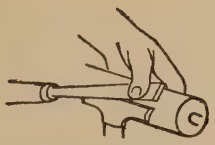
681. Test the diameter with calipers (**44**), holding them lightly as shown, and not pressing them down over the wood.

Leave the piece a little larger than required, to allow for finishing with the chisel.

682. Place the chisel as shown, so that it projects a little over the surface. It is well to begin a little way from the end of the piece lest the edge of the tool catch. Then draw the tool back a little until the lower part of the basil rests on the wood. Hold the tool on the rest with the left hand. The left hand is sometimes laid over the chisel in the position shown in **680**. It is well to keep the forefinger of the left hand hooked under the tee-rest, as this gives firm control of the tool. Then raise the handle slowly a very little, and to the left, until the edge begins to cut. Move the tool steadily to the right, making a smooth shearing cut (**77**). Keep the basil bearing on the wood, but with the upper point of the chisel clear above the surface.[1] The tool can now be turned the other way and the cutting done in the opposite direction. You can sway the body, but keep the feet firmly planted as at first. As you thus trim to the exact diameter, test with calipers.

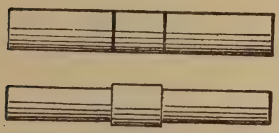


[1] If you keep the basil on the wood, as at A, a very slight raising of the handle will cause the cutting edge to begin to cut, while a very slight movement of the handle downward will raise the cutting edge from the surface, when the cutting will stop. The heel of the basil acts as a kind of pivot, so that you can control the cutting edge by a very slight movement of the handle. If you attempt to work with the basil free from the surface, as at B, you cannot properly control the edge, which may catch or bite or the tool be thrown.



683. The hand is often held around the piece.[1] After moving the switch, or the "shipper," to stop the machine, lay the hand on the pulley, not on the wood, to bring it to a standstill.

684. A tapering form is turned in a similar manner. Rough to shape as already shown. Finish with the skew-chisel, working from the middle toward each end. Begin to cut with the heel of the chisel, continuing with the lower part of the basil as already shown. If the taper is cut wholly with the heel, there is danger of cutting too deeply.

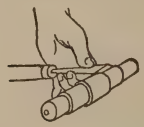


685. To cut a cylinder with one or more steps. First turn a cylinder. Near the middle lay off a space, 2″ for example, with rule and pencil.

686. Hold the chisel (skew or square-edged) with the angle nearly touching the wood, raise the handle slightly and care-

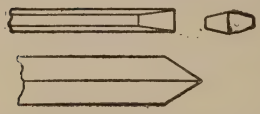
[1] With long slender work a piece of leather wrapped around the hand will prevent burning and the tool can be held against a nick cut in the leather. A back-rest for the work to bear against is sometimes used.

fully so that the corner of the tool will dip down into the wood, at each end of the 2″ space, and cut a groove about $^1/_{16}$″ deep.



687. **As there is but little wood to be removed** it can be done with the chisel as shown. In cutting with the angle of the chisel next the shoulder, lower the handle slightly lest the tool cut too deeply.[1]

688. **Next mark off spaces,** as before, of 1½″ for example.



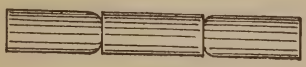
689. **Cut down just outside the lines with the parting tool,** held as shown to a depth of ¼″.

690. **Instead, a V-shaped groove can be cut with the chisel,** first cutting straight down, as shown at the left, and then slantingly, as at the right.

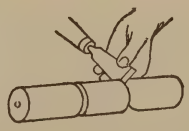
[1] In smoothing the horizontal part where there is a shoulder, place the chisel at an angle similar to that shown, with the heel of the tool pointing toward the shoulder. Then raise the handle and use the tool as already described.

691. Turn to the required dimensions as before, first with the gouge, turning it when near the shoulder so that it will cut as shown. Finish with the chisel as before. See that the ends of the shoulders are smoothed accurately to the lines with the chisel, as already shown in **687.** It is well to practise with a variety of similar steps. The exact dimensions are not important, as the object of such exercises is to get a good working understanding of the process.

692. To cut a V-shaped groove. Place the skew-chisel as already shown, raise the handle and make a cut with the heel of the tool. Then cut one side of the V with the heel of the chisel, the edge being turned from the vertical of course. To make the cut, slide the tool a little way up on the work and then raise the handle, which will cause the heel of the tool to dip down and make the cut, keeping the basil bearing on the wood as already shown, to give you control of the cutting edge. In all these operations the entire edge must not cut, or you may lose command of the tool.

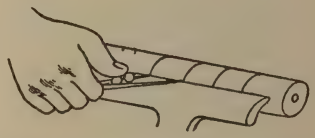


693. To cut a half-bead. After turning a cylinder, cut in with the chisel as shown.



694. Then, place the tool as shown at the left, turn it to cut the half-bead, raising the handle gradually in a curve and pushing the tool forward as is necessary. Remember to let

the basil bear on the wood as a guide. At the end try to cut one shaving from the whole surface. To cut a half-bead in the opposite direction, reverse the positions and movements. This exercise can well be repeated with half-beads of different sizes.

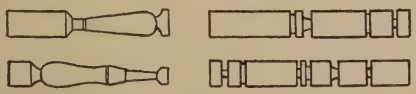


695. To turn beads. Lay out the spaces for the beads on a cylinder with compasses (as shown at the right), or with rule and chisel, making a very slight cut.[1] Pencil marks can also be made for the centres of the beads. Cut down between the beads with the chisel as shown above. Then proceed as in turning two half-beads. Practise with beads of different sizes and also try to make a row of uniform size.

696. To cut off a cylinder or other shape at a given length. Lay off the required length with rule and pencil, leaving a little space at each end,—enough at the live end that the tools cannot strike the spur when cutting in. Cut in carefully with the parting tool a little outside of the line marked. Start with edge of the tool slightly above the center. Raise the handle very slightly as the edge nears the middle of the cylinder, in order to keep the cut as nearly tangential as at first; or hold a ¼″ scraping tool as shown in **689,** with the

[1] Where many pieces have to be marked alike, a gauge can be made by driving brads in the edge of a strip of wood at the required points and sharpening the projecting ends. Holding this gauge lightly against the revolving wood will mark the spaces.

basil down. Make successive cuts lightly to make the opening cut a little wider than the tool to avoid friction and continue until there is only enough wood left to avoid danger of breaking. Or cut entirely with the turning chisel, first straight down, and then slantingly as shown, thus making a V-shaped cut and trimming thin shavings from the end of the part to be kept, until the line is reached and the piece almost cut through. **In trimming an end with the chisel** the basil should be kept nearly flat on the end surface, then a slight movement of the handle will control the cutting. Finally, stop the machine and cut off the ends with knife or chisel.[1]



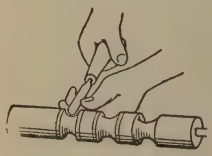
697. To turn a tool handle, as shown at the left. First turn a cylinder roughly. After marking spaces, cut in or "size" down with the parting tool or chisel where the dimensions are naturally measured, as shown at the right.

698. The sizing tool is sometimes used for repeated sizings.

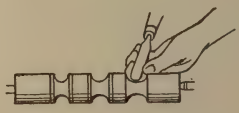
699. Use the calipers as shown, with one end close to the cutting tool. When the calipers indicate the correct diameter

[1] An experienced turner, after placing one hand around the work, cuts through at the live-centre end with the chisel in the other hand, without stopping the lathe.

stop cutting. Do the rest of the turning with gouge and chisel as already described. Have the basil touching the surface and move the handle to one side to keep it so. Finally hold a small piece of folded sandpaper with the forefinger and middle finger and move it rapidly back and forth over the surface.

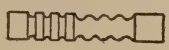


700. **To cut concave curves or hollows.** Turn a cylinder and mark the spaces, hold a small gouge horizontally and at right angles to the work, and remove part of the wood; that is, rough out the curve, but keep well within the lines.



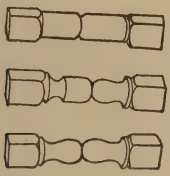
701. **Then hold the tool as shown at the left,** with the basil bearing on the wood, and push it carefully forward and upward, at the same time rolling it partly around, and moving the handle toward the right or left as the cutting proceeds, so that the gouge will work itself up out of the wood at the bottom of the curve. At the end of the cut the tool should be in the position shown at the right. Next cut on the other side of the hollow in the same way, and continue cutting first on one side and then the other until the curve is correct. By this process you make a shearing cut with the grain. By keeping the basil of the tool bearing on the wood as a guide a slight movement of the handle will cause the edge to cut all that is required, and the tool can be controlled so as to cut cleanly and without catching. Practise with hollows of different

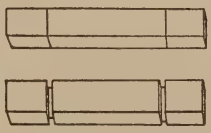
dimensions and try to make a series of uniform size and shape.[1]



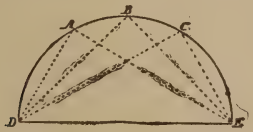
702. To turn a combination of hollows and rounds, cut the hollows first, as shown at the left, and then the convex curves or beads. The sides of the hollows must be cut down straight for some distance to allow for the rounding of the beads. Round the beads with gouge or chisel. The chisel will give a finer surface but the gouge will cut quicker. The experienced turner will cut both rounds and hollows smoothly with the gouge.

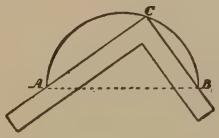
Such simple forms, of various degrees of curvature and in an endless variety of combinations, are the elements with which the outlines of most turned objects are formed.





703. To mark spaces where there are square members, or parts, as shown at the left, do this before setting the lathe in motion, squaring distinct pencil lines across one side of

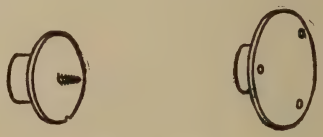




[1] To test the correctness of the curve, use the angle of the square. In a semi-circle chords drawn from any point in the circumference to the ends of the diameter will form a right angle with each other. DAE, DBE, and DCE will be right angles. In whatever position applied, the point (angle) of the square will touch the circumference.

the piece. Cut a groove at the ends of the square members, or make deep V-shaped cuts with the chisel as already shown. Then round the corners of the square members, and proceed for this design as shown at the left.

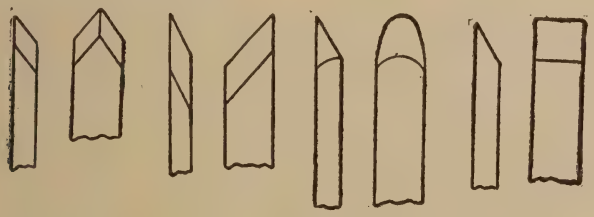
704. Sandpaper should not be used in the earlier exercises, as the pupil should learn to cut rather than scour the wood into shape. For ordinary work cut a small piece of worn sandpaper, double it and hold as shown in **699.** Move it quickly back and forth to prevent scratching the work. In sandpapering sharp curves or beads care must be taken not to injure the shape. The surface can be further smoothed or polished with a handful of fine shavings and dust made by the turning.



FACE PLATE

705. For many shapes, rosettes and cups, for example, the wood must be fastened to the live spindle only. Small pieces can be screwed (by turning the lathe) to the centre screw of the face plate, which is substituted for the spur centre used in the previous exercises. For large pieces screws are inserted through holes in the face-plate. It is common to put a piece of waste wood between the face-plate and the work, to cut against, and care must be taken that the screws are placed so that they will not be struck by the tools when cutting deeply. When the wood is to be cut entirely through, this wood back-

ing is necessary to prevent striking the face-plate. The face-plate can also be enlarged by screwing on a backing piece of greater diameter. The backing can be screwed in various ways to the wood, or in some cases can be glued. The tee-rest can be placed at right angles to the position already shown or at any angle required.



706. Because of the varying angles at which the grain of the wood meets the edge of the tool in such work, it is common to instruct that such turning be done with what are called "scraping tools" which are of various shapes, and have the basil on one side only.

They can have the edge turned to form a scraping burr, by rubbing on an oilstone. These tools are held horizontally on the rest with the basil down. The skilful, experienced turner, however, does the greater part of his turning with the regular tools already mentioned and on the same general principles of cutting that have already been described, and uses the scraping tools only when necessary. The beginner should learn to do his work as much by clean cutting and as little by scraping as possible. There are, however, some operations which can be done only by scraping.[1]

707. To turn a disk. Cut off the corners with a hand-saw or saw approximately to shape with the band-saw. Screw to the screw chuck and mark with compasses. Place the tee-rest as shown, about $1/8''$ from the surface and parallel to it, as shown in the third illustration. Cut the edge with parting

[1] If the work be large, use a slower speed for the roughing out and a higher speed for the finishing.

tool. It is common to put a piece of waste wood between the face-plate and the work, to cut against. The edge can be fin-

ished, or cut entirely, with gouge and scraping chisel held in the position shown in the last illustration, but a light cut must be taken to prevent chipping.

708. Turn the face with gouge and scraping chisel, or scraping chisel alone, or skew chisel. Work from the centre toward you; that is, entirely between the centre and the edge nearest you,—never beyond the centre, for the further half of the wood is moving in the wrong direction. Test the straightness of the surface by eye and with straight-edge.

709. The disk in 707 can be turned into a rosette.

710. Some kinds of work have to be held in a chuck. For example, after turning the upper side of the candlestick base shown in the first illustration, screw a piece of wood to the face-plate and turn a recess in it of the right size to tightly hold the turned base as shown in the last illustration. The depression in the bottom of the latter can now be turned.

711. Spheres and rings are turned on this principle carried farther. There are various forms of chucks for different problems. When the beginner has acquired enough skill to undertake work of this kind, he should seek a competent instructor or books on turning which go thoroughly into these more difficult problems.[1]

712. The general principle of finishing turning is the same as with other work (394). The wood can be filled, if required, and the filler cleaned off with shavings. A common way to polish is with a pad. Put a little oil on a cloth, pour on shellac and make a pad to hold against the work, on the same principle as French polishing (406, footnote). Shellac can also be applied with a brush, revolving the work by hand, and afterwards rubbing down in the usual way. Wax can be used.

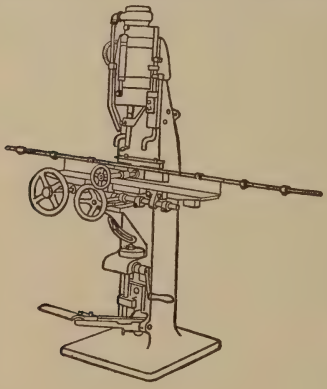
713. Lathes are also adapted for screw-cutting, and have various tool-holding and self-feeding attachments—also knife attachments by which patterns can be turned automatically at great speed, and appliances for turning a great variety of odd shapes, as twisted or "rope" patterns,—but such matters belong to advanced work and manufacturing purposes rather than to the elementary principles of hand-turning.

[1] To turn a ball or sphere the process can be the same as with the beads already shown, turning until the wood is nearly cut through, when the ends are cut off in the usual way. The curvature can be tested with a templet. Then make a form or "chuck" in which the sphere will be held firmly. With the chuck and sphere screwed to the face-plate, the sphere can be finished accurately. This requires turning the sphere repeatedly in the chuck to expose new parts to be finished, an operation calling for experience and judgment. When the sphere becomes too small to be held by the chuck, the latter must be altered.

A templet, or pattern, is sometimes used to secure accuracy in turning some shapes. It is merely an exact reverse outline of the required form cut in sheet metal or thin wood and applied to the work to test it. Stop the lathe before applying the templet. It is best to learn to turn by eye as far as possible and to resort to such tests only when necessary.

MORTISING MACHINES

714. Mortising machines. The mortise is cut by repeated strokes of a chisel, by borings of a bit, or by a combined arrangement of bit and four-sided hollow chisel. Mortising attachments are made for saw-benches, and there are foot-power machines. Mortisers should have the light come from the side. The arrangement, adjustments, and other details should be learned directly from the machine you are to use, for there are many kinds in use. While mortising machines are necessary in factory work, they are not essential for the beginner, or amateur, because a small amount of mortising can be done well enough by hand (467).



715. The face-side or joint-edge of the stock is kept against the gauge or fence.

The motor can be mounted directly on the boring spindle and both slide back and forth together to make a mortise. The table can be raised or lowered to suit the size of stock to be mortised, and can have slots through which fixtures or gauges can be clamped. The table can be moved to and from the bit by a lever, or by power feed, and be fitted with stops to regulate the depth of mortise.

TENONING MACHINES

716. Tenoning machines. Important for factory production, but not essential for the beginner, amateur, or general student, because tenons can be cut with the bench saw rapidly enough for the demands of general work. There are different kinds of machines and the arrangement, adjustments, and other details should be learned directly from the machine to be used. It is considered a dangerous machine and should be safeguarded as much as possible.

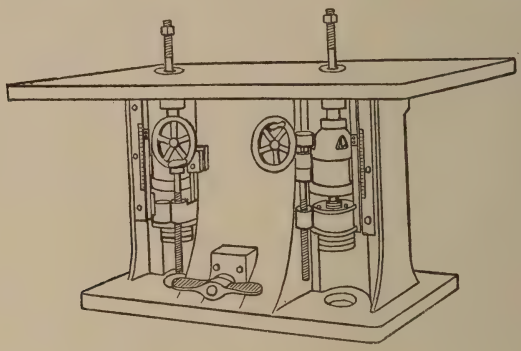
717. Some machines make the tenon wholly by saws. It can be cut at one operation by five circular saws, each driven by a motor mounted on its arbor. Two cross-cutting saws, one above and one below the wood, cut the shoulders of the tenon, one cross-cutting saw cuts off the end of the tenon, and two splitting-saws, one above and one below, cut the sides of the tenon. The table which supports the wood can have a movable gauge and a clamping device, as well as slots through which various fixtures can be clamped. The table can be tilted, and be on a carriage which rolls on a track. The work can be fed to the saws by moving the carriage along until the tenon is cut.

718. Another type of machine cuts the tenon by knives attached to revolving cutter-heads. Spurs score the shoulders in advance of the cutting knives to cause clean cutting. There can also be an arrangement for coping or making variations in the shoulders, as is sometimes required.

MOULDING MACHINES

719. Moulding machines are either horizontal or irregular. The former are used to get out matched boards, straight beading, reeding, strips of moulding, and the like. The stock is passed through the machine as through a planer, and is cut by knives shaped to fit the pattern required. Such machines are essential to factory production, but are not impor-

tant for the beginner, amateur, or general student, because the product of these moulders is for sale almost everywhere.

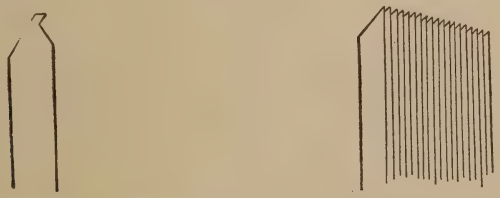


720. **The Shaper or irregular moulder** cuts the edge of the wood into any desired shape for which cutters can be fitted. A first-class shaper will mould the wood in any direction of the grain and leave the surface so smooth that no further finishing is required. The shaper has always been regarded as a dangerous machine—one with which the novice should not experiment. It has two vertical spindles (or sometimes only one) with collars which hold cutting knives of whatever shape may be required. These knives revolve rapidly with the spindle like the cutters of the Planer or Jointer, and cut the wood as the operator passes it by them. The form into which the wood is cut is of course the reverse of the shape of the cutting-knives. The two spindles revolve in opposite directions, so that the operator can cut according to the direction of the grain. If there is but one spindle, the direction can be reversed.[1] Safety guards can be used.

[1] "The essential features of a successful shaper are primarily the design and construction of the frame and table, the extent to which all vibration is eliminated, the type and arrangement of spindle and boxes. The machine must be so made that the spindle can be run at the highest practical speeds with perfect steadiness, as the lightest vibration or chatter will produce imperfect work."—*Baxter D. Whitney and Son, Inc.*

SCRAPING MACHINES

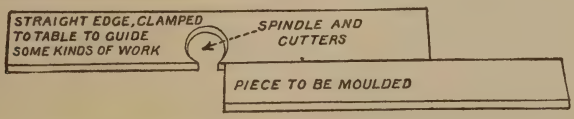
721. Scraping machines. Valuable where much fine finishing of flat surfaces is done. The stock is run through as with a planer, and is scraped by a knife with a turned edge, working on the same principle as the hand scraper (**194-6**). This leaves an even and satin-like surface,—a glossy finish superior to that produced by sandpaper. Such machines are made as wide as 64″ and will scrape material as thin as $^{1}/_{16}$″, and upwards, very economically in regard to time and upkeep. There is removed from the surface a continuous shaving which may be as thin as tissue, or as heavy as the thickest wrapping paper. By substituting a toothed knife, solid or built-up work can be toothed ready for gluing.



722. Showing scraper with turned edge and toothing knife.

SHAFTING, PULLEYS, BELTS, ETC.

723. All lines of shafting and all machinery should be set up exactly level and all connecting pulleys exactly in line.



Mortising and "lock cornering" (**539**) can be done with a head consisting of alternate grooving cutters and collars of equal thickness. By attachments routing and dovetailing can be done. Small shapers are made to be connected with a light socket.

A countershaft (674) enables a machine to be started or stopped without affecting the running of the main shaft, and is belted directly to the machine and also to the main shaft. The latter belt runs on either of two pulleys, side by side, on the countershaft—one tight, the other loose. When the belt is shifted to the tight pulley the countershaft is turned and the machine set in motion. When the belt is on the loose pulley the countershaft and machine stop, while the loose pulley continues to revolve. The belt is shifted from one pulley to the other by one or more levers. Loose pulleys are apt to give trouble and must not be neglected.

724. **Motors** connected directly with each machine have obvious advantages, as dispensing with the care, danger, and expense of shafting and belting, and also avoiding the need of running main shafting when only part of the machinery is in use.

725. **Pulleys and Belts.** It is better to have large pulleys than small, but the relative sizes must be regulated by the speed required.[1]

[1] To find the speed of a pulley to be driven by another pulley, multiply the diameter of the driving pulley by the number of its revolutions and divide by the diameter of the pulley to be driven.

To find the necessary diameter of a driving pulley to give a required number of revolutions to a driven pulley of given diameter, multiply the diameter of the pulley to be driven by the required number of revolutions and divide by the number of revolutions of the driving pulley or the driving shaft.

To find the necessary diameter of a driven pulley in order that it may revolve at a required speed, multiply the diameter of the driving pulley by its number of revolutions, and divide by the required number of revolutions of the driven pulley.

A speed of three thousand feet a minute is as fast as a belt should run in ordinary cases. For small pulleys and narrow belts 15 feet between shafting is a good distance, but for larger pulleys and belts a greater distance is better, although it is common practice to use much shorter belts.

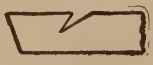
To find the length of a belt, add the diameters of the pulleys, divide by two, multiply by 3.1416 and add twice the distance between the centres of the shafts. Belts are frequently too tight.

726. To make a machine run in the opposite direction from the shaft, which is sometimes necessary, the belt must be crossed between the pulleys.

727. Belts are of leather, rubber, etc. The hair side of a leather belt, being the weaker side, should be in contact with the pulley. There are various metallic fasteners for belts, which are easily applied,—also lacing of wire, and sewing with tough wire, using short stitches. The ends can also be shaved tapering, to lap over one another, and glued or riveted. Belt lacing machines are in common use.[1]

728. To throw a belt off a pulley, press with a stick at the edge of the belt where it runs on to the driving pulley. To slip a belt on, do so in the direction of the power. Fit the belt on the driven pulley, and slide it onto the driving pulley with a stick, at the point where it is to run on to the pulley. Large belts are usually thrown on and off by hand, but hold the hand straight with the fingers extended, and use it somewhat like the stick. Do not grasp a belt when throwing it on or off, but merely slide it on with a quick motion, keeping the fingers stiff.

729. Oiling. With the old-fashioned boxes where there is simply an oil hole, keep the holes clean and oil every morn-



[1] There are various ways of using the rawhide belt-lacing. A common way is shown. Before lacing, cut the ends of the belt squarely across, using the try square. Punch holes with a belt punch. All crossing of lacings, whether leather or wire, must be on the outside. The lacing on the inside which comes against the pulley must run lengthways of the belt, as it would soon wear through if crossed. There are two thicknesses on the inside. To fasten the ends cut a little nick in the edge of the lacing at such a point that, when pulled through an extra hole made for the purpose with a knife, the nick will catch and keep the end in place.

ing before beginning work. Modern machinery is provided with devices of various kinds, which make it necessary to oil at long intervals only. These save much trouble and greasiness, although open to the objection that as the oiling is not a matter of daily routine it may be neglected until after the bearings have become dry. Sliding ways and other slowly moving adjustments, should be kept wiped and oiled.

QUESTIONS

COMMON MACHINES. 1. *If you could have but three machines for general woodworking, which would you choose? In what order would you place them in regard to importance? Why?*

CIRCULAR SAW. 2. *Show how to avoid the chief dangers from the circular saw.*

3. *How much should the saw project above the table? Why?*

4. *Show the process of rip sawing.*

5. *How can you safely push narrow pieces past the saw?*

6. *If necessary to stop ripping instantly, what should you do?*

7. *Do you advocate making glue joints with the circular saw? Why?*

8. *Show the process of cross cutting.*

9. *How can you cut a number of pieces of the same length?*

10. *Show how to use a clearance block.*

11. *Show how to cut a groove or a dado with a common circular saw—how to wabble a saw.*

12. *Show how to cut a rabbet—a stop rabbet.*

13. *Show how to cut a tenon.*

14. *Show how to cut wedges or tapering pieces.*

15. *Show how to make a jig for cutting octagonal sticks—for cutting fillets.*

16. *Show how to rough out mouldings and the like.*

17. *Show how to partially rough out circular hollows.*

SWING SAW. 18. *For what is the swing saw used? Show how it works.*

BAND SAW. 19. *What are the advantages of the band saw? Has it any disadvantage for curved work?*

20. *What dangers are to be avoided?*

21. *Show the process of sawing.*

22. *Show how to cut curved work which has to be sawed from two adjacent sides.*

JIG SAW. 23. *Compare with the band saw. What one advantage has the jig saw? What disadvantages?*

24. *Show the process of sawing holes or enclosed openwork.*

PLANER. 25. *Make sketch showing the principle upon which the single surfacer works.*

26. *To make a warped surface flat, what must you do?*

27. *Show the process of planing—to plane tapering.*

JOINTER. 28. *What are the functions of the jointer?*

29. *Show the principle upon which it works.*

30. *Show how to adjust the tables and knives.*

31. *Show how to avoid danger from the cutters.*

32. *Show how to plane warped stock.*

33. *Show how to plane tapers—to bevel—to cut a rabbet.*

SANDERS. 34. *What are the common forms of sanding machines?*

35. *Show the principle of the drum sander—the disk sander—the spindle sander—how to sand curves.*

36. *What advantages has the hand block belt machine?*

BORING MACHINES. 37. *Show the principle of boring machines, and the process of boring.*

LATHE. 38. *Illustrate the principle of the lathe.*

39. *When a countershaft is used how can you regulate the speed?*

40. *Show the general process of turning a cylinder.*

41. *Show how to use the calipers.*

42. *Show how to lay off spaces on the work.*

43. *Show how to control the cutting with the basil of the tool.*

44. *Show how to cut beads—to cut hollows.*

45. *Show how to cut off the wood at the required length.*

46. *Illustrate the general principle of face-plate turning—of turning with chuck.*

47. *Show how to use sandpaper, and how to finish.*

MORTISING MACHINES. 48. *What is the principle of the mortising machine? How is the cutting done?*

TENONING MACHINES. 49. *In what different ways are tenons cut?*

SHAPER. 50. *Show the principle of the shaper and how the cutting is done.*

SCRAPING MACHINES. 51. *How does the scraping machine work? What are its advantages?*

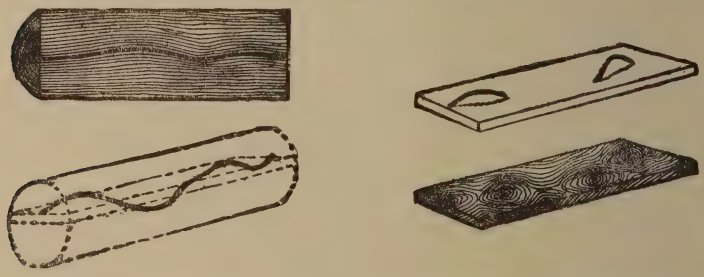
POWER. 52. *Compare the application of power by countershaft and by direct motor drive.*

53. *Show simple ways to lace a belt.*

54. *Show how to throw a belt on and off.*

WOOD

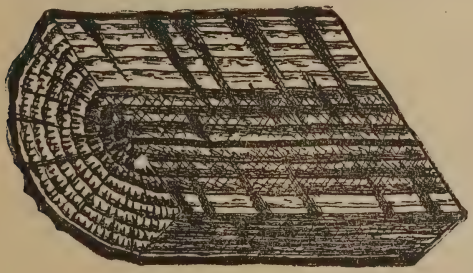
730. Selecting the stock. First, the wood must be of a kind suitable for the work. Strength, weight, cost, appearance, hardness, ease of working, toughness, durability, elasticity, suitability for finishing, and other qualities have to be considered in many cases. It all depends on what you are going to make. Except for rough work, use dry, clear, straight-grained, well-seasoned stock, flat (that is, not warped or twisted), and free from knots and other defects.[1] Choose stock of such dimensions that there will be as little waste as possible. Your Stock bill (Bill of Materials) gives the number and sizes of the parts. The rest is a matter of measurement, experience, and common-sense. It is usually cheaper to get small parts



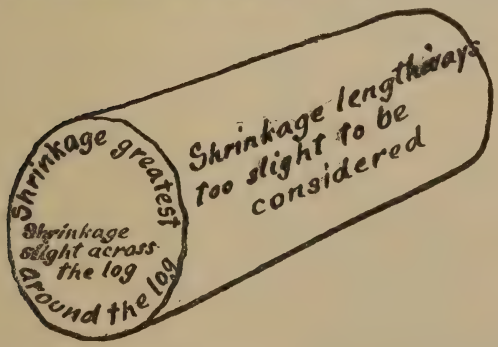
[1] Showing crookedness of grain due to the tree being crooked when young, so that the heart frequently is not in the centre of a straight tree. Such crooked grain increases the tendency to twist and warp, because there is so much end-grain on the surface of the boards, which absorbs and releases moisture more rapidly than the side-grain.

out of left-over pieces on hand, but this often takes more time. For small work you can often buy short stock, and you can buy "squares" also, i. e., square stock of various sizes.

731. **End of log, showing annual rings, sap-wood and heartwood.** Also the pith rays (medullary rays), radiating from the pith at the centre. Medullary rays are found in all wood used for woodworking, and are very conspicuous in oak.

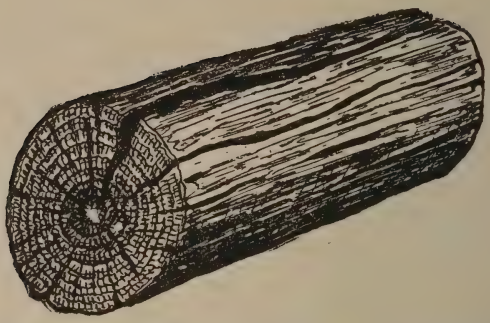


732. **Log cut lengthways,** showing annual rings forming the lines or streaks, commonly called the "grain" (292), of a board or other piece of lumber. Also, showing the medullary rays.

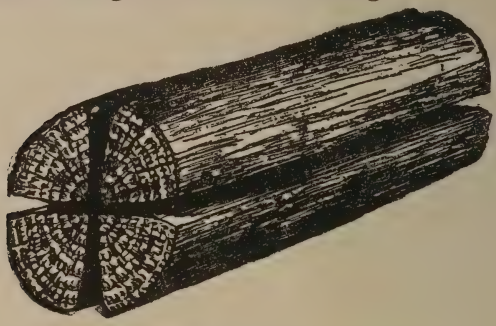


733. **A green log contains much water.** In drying it shrinks most around the log, not so much across it, and very little lengthways.[1]

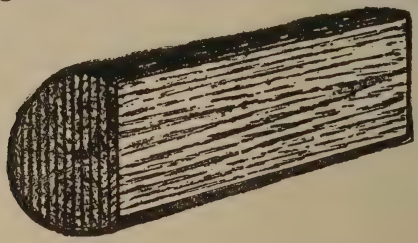
[1] "The shrinkage from the green to the oven-dry condition across the grain for a flat-sawed board is about 8 per cent. and for a quarter-sawed



734. **Showing result of this unequal shrinking,**—lengthways cracks running toward middle of log.



735. **Halving or quartering the log** exposes the inner part, so that drying is more uniform, and the cracking less



736. **Slash or plain sawing** (the common way).

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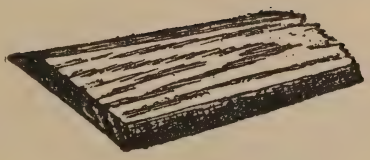
(739) board about 4½ per cent., while the shrinkage parallel to the grain is practically negligible for most species."—*Forest Products Laboratory.*

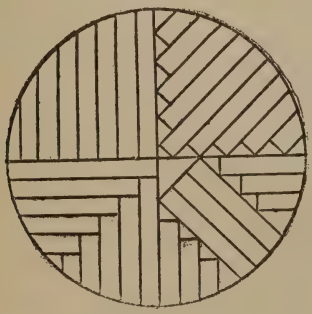


737. Strongly figured grain often results from plain sawing, with woods like oak, chestnut, ash, etc., particularly in the outer boards.

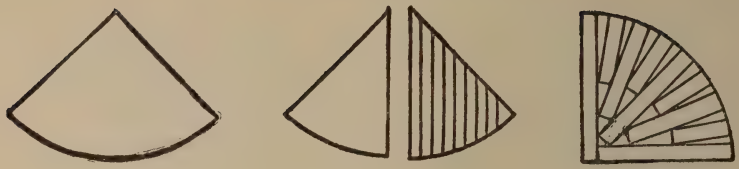
738. Showing how boards, planks, etc., sawed from a log have the same tendency as the whole log to shrink unevenly.

The middle board does not curl. The others curl or cup away from the heart, because the sapwood on the outside contains more water than the heart and so shrinks more in drying. Boards nearest the middle are the best, because they curl the least, are the widest, and have the least sapwood, which is usually inferior. All the boards shrink in width, and become thinner toward the edges.

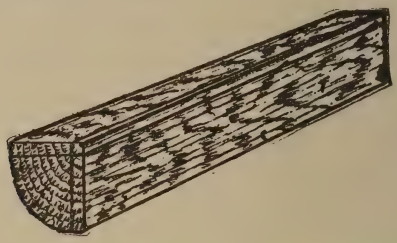
739. Quarter-sawing. The log is first quartered, and then each quarter sawed by itself. Radial sawing gives the best



boards, but wastes more lumber than other ways. Quarter-sawed lumber shrinks more in thickness than plain-sawed, but this is usually of less importance than shrinkage across the wide surface. Quarter-sawed lumber holds its shape much

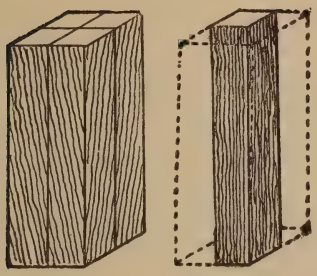


better than plain-sawed and is therefore better for work of a high grade. The middle board sometimes has to be divided, because it contains the pith.

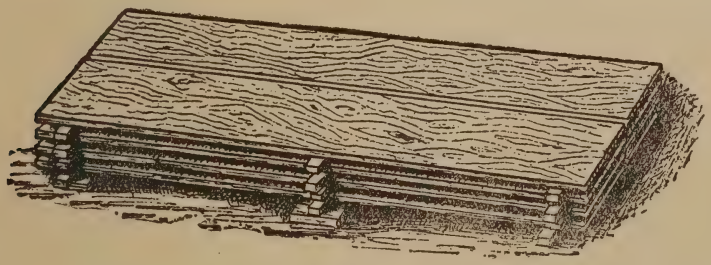


740. Showing figure formed on the surface by the medullary rays, as in quartered oak.

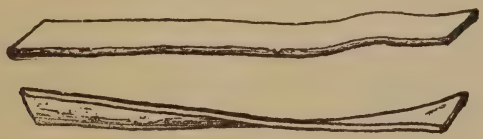
741. Showing shrinkage of timber sawed from different parts of log. The centre piece holds its shape best. The best way to cut flooring is shown by A. It will shrink the least and wear best. A timber is stiffer if the annual rings are like B than if like C.



742. Rift (or split) stock is stronger than sawed, unless the wood is perfectly straight-grained. Four cross-grained, weak pieces can be sawed from the block shown. One strong, straight-grained piece can be obtained by splitting, that is by following the grain. The split or rift piece is suitable for a hatchet handle or a stout pin, for example. The four sawed pieces are not.



743. Boards " stuck " for seasoning, so that the air can circulate between them. The sticks must be directly over one another.



744. Results of carelessness in " sticking."

745. The old-fashioned air-dried stock (usually containing 15% or more of moisture) is hard to find. Lumber is now dried in kilns by artificial means, and is claimed to be stronger and less liable to decay than if air-dried.[1] The amount of moisture is usually reduced to 5% or 6% for furniture and cabinet work, while for other work from 8% to 12% is common, but this is a matter of judgment.

746. Seasoned wood is lighter in weight than green, dryer to the touch, usually has a different odor, and cuts differently. A piece you whittle breaks off differently. One test is to rap the boards sharply with a hammer. A green piece and a dry one will have different vibrations and give out different sounds. Saw, plane, whittle, break the shavings.

747. All wood, no matter how thoroughly seasoned or protected by paint or varnish,[2] expands and contracts in width. Moisture (humidity) makes it expand. Dryness makes it shrink. Heat makes it shrink, unless the humidity increases in proportion. These changes cannot be prevented,[3] and must

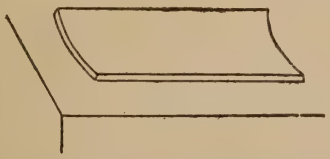
[1] Lumber air-seasoned for years under cover has always been considered the best. Since kiln-drying came into use, air-seasoning has been less and less done, because kiln-drying saves much time, investment of capital, etc., but the result until recently has been much inferior to air-drying. Great improvements have been made lately in the kiln-drying process. The Forest Products Laboratory reports that "to all intents and purposes lumber which has been properly kiln-dried is equivalent to that which has been air-seasoned under the best conditions." Whether common commercial kiln-drying is yet done in the best way however may certainly be a question, and if your work requires toughness, elasticity, and "life" in the wood, it may be well to use air-dried stock if you can find it, until common kiln-drying has been still further improved. Soaking in water first assists in the seasoning, but long soaking may lessen the toughness. Small pieces can be smoked.

[2] The only coating which will prevent wood absorbing moisture, according to the Forest Products Laboratory, is aluminum leaf.

[3] The power developed by the expansion of wood can be seen in the common operation of splitting rocks by drilling a row of holes, driving dry wooden wedges into them, and then wetting the wedges, when the rock will be split by the swelling of the wedges.

be allowed for, in many kinds of work, or the wood will either be buckled or split or the work forced apart (See **326, 376, 379, 382** footnote, **387, 484, 540**). Cracks, curling, warping, winding, or twisting of wood are due to irregular and uneven swelling or shrinking. As a rule the heart side will be less affected by atmospheric changes than the bark side.

748. Lay a board on the ground in dry weather and you will soon find it curled or warped, because although dry on the upper side it has absorbed dampness on the under side. Even laying a board flat on a bench or on the floor will cause it to curl, because it is more exposed to the air on one side than on the other. Therefore keep your stock of lumber so that each piece will be equally exposed on all sides to heat and cold, moisture and dryness, if possible. After planing or trimming stock leave it on edge or on end, not flat on the side.



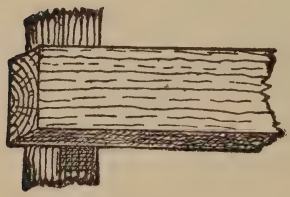
749. Common result of laying a board flat. Keep your stock carefully stuck, which tends to keep the pieces straight and true. Never lay good boards down flat upon one another, unless they are thoroughly seasoned. The top board will warp. Keep short pieces, which it is not worth while to "stick," standing on end, equally exposed on all sides to heat and cold, moisture and dryness.[1]

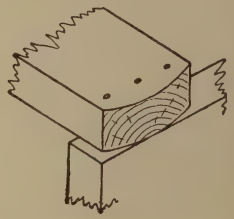
750. Stock for nice work must be kept and used where it is dry, or when the work is removed later to a dry place it

[1] Attempts to permanently flatten a warped piece of dry wood are seldom worth while with common stock. In case of an heirloom or something rare, remember that wetting one side tends to make that side expand; applying heat, to make the heated side concave. Soaking in boiling water, pressing into shape (or bending the other way), and leaving until dry can also be tried. But it is hard to permanently flatten warped stock.

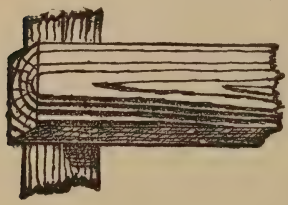
will shrink or warp, and perhaps be ruined. Where wood has been exposed to damp air, as in a shed or cellar, let it stand in the warm shop for some time before using it for nice work.

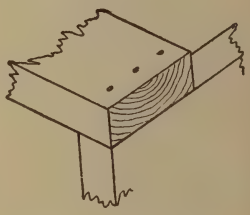
751. **When warping or change of shape would be particularly harmful,** first get the stock out roughly to shape but too large, and leave exposed to the air on all sides. Allow some time for it to warp or twist. Then you can cut to the exact shape without much subsequent change of form.[1]





752. **Boards or plank exposed to the weather** are more durable if laid heart side down, but are more apt to curl up at the edges than if heart side up.





753. **If laid heart side up they will lie flatter,** but the action of the atmosphere, water, sun, etc., will tend to separate the layers and fibres.

754. **Warping is often avoided** by building up with a number of narrower pieces so arranged that their warping

[1] A golf-stick, a gun stock, a bow, a billiard cue, for example, should be roughed out, considerably too large, then hung up for further seasoning. When reduced to shape later, it will hold its shape better than if it had been entirely shaped at one time.

tendencies will counteract each other (534). Often done for bench-tops, frames of machines, etc.[1] See 365.

755. Always try to treat both sides of a board alike. If you have an inch board planed down by machine to three-eighths of an inch, for instance, have it planed equally, as nearly as may be, from both sides. It is common to simply smooth off, or "surface" one side, and then plane the board down on the other side, often making it warp badly at once.

756. Hard wood is that from broad-leaved trees, as the oak, while soft wood comes from the coniferous or needle-leaved trees,[2] as the pine. Dry wood is harder, stiffer, and stronger than green, but more likely to break. Green wood is tougher and will bend and resume its former shape better. As a rule heavy wood is stronger and stiffer than light wood, and hard woods are usually stronger than soft woods, though there are exceptions. Heavy wood swells and shrinks more than light, which will usually hold its shape better. Sapwood changes more quickly than heartwood.[3]

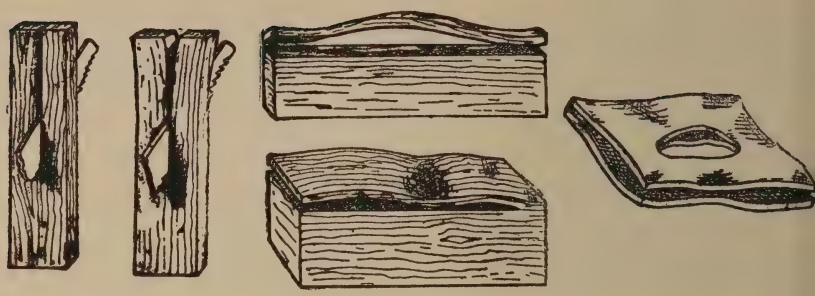
[1] Where but one side of a board is seen or used, and where the full strength is not needed, as in a drawing-board, warping and twisting can sometimes be largely prevented by lengthways saw-cuts (easily made with the circular saw) on the back or under surface, the crossways strength required being secured by cleating or other devices. Doors and most forms of panelled work also illustrate methods of preventing damage from swelling and shrinking (372).

[2] This distinction is based on botanical reasons and is sometimes puzzling. For instance, whitewood of the hardwood class is softer and easier to work than hard pine of the softwood class.

[3] "Some hardwoods are weaker than some softwoods; and some softwoods, notably long leaf pine, are stronger than many hardwoods."—*Kellogg. Lumber and its Uses.*

"Other factors being equal, the strength of wood is roughly proportional to the dry weight."—*Kellogg.*

"Heartwood is generally heavier than sapwood, and fully as strong if equally free from defects. Moreover, it is usually much more resistant to decay. On the other hand, since its cells are more open, sapwood usually absorbs wood preservatives better than hardwood."—*Kellogg.*



757. **Re-sawing of dry** stock is uncertain. Showing results which sometimes occur (re-sawed mahogany—exaggerated merely because of the short length of the drawings). Re-sawing is often satisfactory, but it is usually safer to buy wood of the right thickness than to split or re-saw thicker stock.

"The sapwood is, as a rule, darker in the whitewood class than the heartwood, whether seasoned or unseasoned, but is paler in color in most hardwood trees which have had time to season. In some of the white, or softer woods, when fresh cut, the difference is scarcely perceptible; but exposure to the air quickly gives to the outer layers a greenish tinge, due to a species of mould fungi which attacks them."—*Laslett and Ward.*

There is a distinction between the elasticity needed for such purposes as a bow or springboard, and the toughness required for the ribs of a canoe, or the wattles of a basket. In the former case the material must not merely bend without breaking, but must spring back (or nearly so) to its former shape when released, as with lancewood or white ash; while in the latter case it must bend without breaking but is not required to spring back to its original form, as with many green sticks which can be easily bent but have not much elasticity. These two qualities are found combined in varying degrees in all woods. Elastic wood must necessarily have toughness up to the breaking point, but tough wood may have but little elasticity. As a rule, wood from a young tree is tougher than that from an old one; the best, hardest, and strongest in the young tree usually being nearest the heart, while in an old tree the heart, having begun to deteriorate, is softer and not so good as the more recently formed growths nearer the sapwood. If the tree is in its prime the wood is more uniformly hard throughout. The sapwood, as a rule, is tougher than the heartwood, though usually inferior in other respects; and timber light in weight is sometimes tougher than heavy wood, though the latter is often stronger, more durable, and prefer-

758. Plywood. To save expense and to prevent warping, winding, etc., several layers of very thin wood are glued together under pressure, with the grain running in different directions. This principle was often used by the Ancients. When there are three layers, as shown, the middle one is often thicker than the others. Frequently more than three layers are glued together.

HEART-SHAKES STAR-SHAKES CUP-SHAKES

759. Three common defects in lumber, due to uneven shrinkage, swaying of the tree in the wind, decay, or other causes.

760. Knots are merely the beginnings of limbs. A smooth trunk often has knots inside, due to limbs which died or were removed. For some work tight knots do no harm, but loose knots are bad for all but the roughest work. A spike knot is one which has been sawed through lengthways. Wood containing streaks of pitch and pitch-pockets should not be used for nice work.

761. Preservation of lumber. Thorough seasoning, protection from sun and rain, and ventilation are the essentials for the preservation of wood. It decays fastest when alternately wet and dry, as parts of the piles of a bridge, or fence posts, etc.; or when kept in a close, moist atmosphere, as

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able for many purposes. In elm, ash, and hickory, the sapwood is sometimes considered better than the heart. The growth and structure of trees is a very complex matter, however, and the diversities almost infinite.

timbers over a damp, unventilated cellar. Wood kept under water resists decay. When protected from atmospheric changes it lasts very long as is illustrated by recent Egyptian researches.

762. Decay can be much retarded by treating wood with creosote, zinc chloride, sodium fluoride, or other preservatives. The Forest Products Laboratory reports that charring the lower ends of fence posts is not worth while.

Creosote stains, coal tar and wood tar or pitch, applied hot, in thin coats, to dry wood are good. Much wood is now impregnated with preservatives by various processes. Any thick coating like paint or tar should be applied only to thoroughly seasoned wood.

QUESTIONS

WOOD. 1. *Define annual rings, heart wood, sap wood, medullary rays.*

2. *Explain slash or plain sawing—quarter sawing.*

3. *Show how the different boards sawed from a log shrink and curl. Which keep their shape best?*

4. *What advantages from quarter sawing?*

5. *How can you recognize quarter sawed lumber in case of oak and some other woods?*

6. *What advantage has rift stock?*

7. *Why is lumber "stuck" for seasoning? What is essential in sticking?*

8. *Compare air seasoning and kiln drying.*

9. *What causes green wood to shrink? How much may it shrink in width when it becomes very dry?*

10. *What causes dry wood to swell?—to shrink?*

11. *What causes it to crack, curl, warp, and wind?*

12. *Why is crooked-grained wood more subject to warping and winding than straight grained?*

13. *If the expansion and contraction of wood cannot be prevented, what should you do in good work? In which direction does wood change the least?*

14. *How should stock be stored? Why? Why should you not lay a board flat on the floor or bench?*

15. *Why is it essential for nice work, to keep stock in a dry, warm atmosphere?*

16. *Why is it best to plane equal amounts from each side of a board?*

17. *What reasons are there for building up stock with several pieces?*

18. *Define hard wood—soft wood.*

19. *Compare heavy and light wood, dry and green wood, in regard to strength, toughness, and other characteristics.*

20. *Which usually changes shape more, light or heavy stock?*

21. *Compare heart wood and sap wood.*

22. *Which side up should you lay boards exposed to the weather? Why?*

23. *What is plywood?—when used?*

24. *Name three kinds of shakes and define them.*

25. *How can you account for knots in boards sawed from a log which was smooth on the outside?*

26. *What conditions are essential for the preservation of wood?*

27. *With what can wood be treated to retard decay?*

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